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A study of the adequacy of the Navy Industrial Fund accounting system for use with the RAMP SMP facility

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THESIS

A STUDY OF THE ADEQUACY OF THE NAVY
INDUSTRIAL FUND ACCOUNTING SYSTEM FOR
USE WITH THE RAMP SMP FACILITY

by

Michael Bentley Bryant

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This thesis describes the RAMP SMP facility, discusses the accounting issues which arise when automated manufacturing techniques are introduced, provides an overview of the NIF accounting system, and analyzes the NIF accounting

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A Study of the Adequacy of the Navy Industrial Fund Accounting System for use with the RAMP SMP Facility

by

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I. INTRODUCTION

A. THESIS OBJECTIVE

The purpose of this thesis is to determine the adequacy of the Navy Industrial Fund Accounting System (NIF) for use with the Navy's Rapid Acquisition of Manufactured Parts Small Manufactured Parts (RAMP SMP) facility currently under construction in Charleston, South Carolina.

The RAMP SMP facility will incorporate state-of-the-art Flexible Manufacturing Systems (FMS) and Computer Integrated Manufacturing (CIM) technology. FMS and CIM imply a major shift from labor intensive to capital intensive manufacturing processes and result in changing cost behavior patterns. Current literature suggests and private sector experience confirms that traditional cost accounting systems, designed for labor intensive manufacturing processes, fail to provide cost information needed in the automated manufacturing environment.

Current plans foresee establishment of RAMP SMP capabilities in Navy Industrial Fund (NIF) activities. This would make accounting for RAMP SMP the responsibility of the NIF cost accounting system. The cost accounting system for NIF activities is based on traditional cost accounting principles and procedures and, therefore, is potentially

subject to the same problems as private sector accounting when dealing with automated manufacturing processes.

This thesis examines the manufacturing processes incorporated in the RAMP SMP facility, cost accounting issues related to automated manufacturing processes, and the NIF Cost Accounting System. It then analyzes the data listed above and draws conclusions as to whether or not the NIF cost accounting system is adequate for use with RAMP SMP-type facilities.

Although the analysis conducted in Chapter V is intended to identify potential problem areas, this thesis remains focused on the question of the NIF system's overall adequacy for RAMP SMP application. It is not intended to offer solutions to specific problems. Developing solutions to the problems this thesis identifies is recommended as the topic for a follow-on thesis.

B. BACKGROUND

In the early 1980's, the Naval Supply Systems Command (NAVSUP) assumed responsibility as Lead Systems Command for Navy Logistics Research and Development and Manufacturing Technology. [NAVSUP, 1986] Based on this responsibility and Department of Defense (DOD) initiatives to improve weapon systems' logistics support, NAVSUP gave birth to the Rapid Acquisition of Manufactured Parts (RAMP) Project. [FAI-A, 1986] RAMP seeks to increase fleet readiness by adapting existing industrial FMS and CIM technology to

produce low volume, commercially unavailable, parts on demand. [NAVSUP, 1986]

Availability of spare parts is a critical factor affecting fleet readiness and operational availability. [NAVSUP, 1986] Yet NAVSUP foresees a future environment characterized by diminishing manufacturing sources, outdated manufacturing techniques, low levels of competition, and restrictive proprietary rights resulting in poor availability, long leadtimes, and high procurement costs for low-volume spare parts. [FAI-A, 1086] NAVSUP sees RAMP as the solution to this problem.

Through implementation of the RAMP concept, NAVSUP envisions the following benefits:

- Enhanced fleet readiness and operational availability [NAVSUP, 1986]
- Reduced leadtime [NAVSUP, 1986]
- Reduced cannibalization from operational units [AMRC-A, 1988]
- Increased competition [NAVSUP, 1986]
- More efficient production [NAVSUP, 1986]
- Reduced parts cost [AMRC-A, 1988]
- Reduced inventory cost [AMRC-A, 1988]
- Transfer of RAMP technology to the industrial base [NAVSUP, 1986]
- Enhanced surge and mobilization capabilities [FAI-B, 1986].

Specifically, NAVSUP seeks to reduce average leadtime for those hard-to-get parts from 300 to 27 days and to

increase System Material Availability (SMA) to 95 percent. [FAI-B, 1986]

The RAMP Project is still in the Concept Demonstration and Validation Phase. NAVSUP is working with the South Carolina Research Authority (SCRA) to develop RAMP capability to produce small manufactured parts (SMP) and printed wiring assemblies (PWA). [FAI-A, 1986] The resulting RAMP systems will initially be installed in a RAMP Test and Integration Facility (RTIF) currently under construction in Charleston, South Carolina. Development will continue at this location until its full operational production capability is demonstrated. [Houts, 1986] Once the system's full capabilities are realized, NAVSUP hopes to install RAMP SMP and PWA facilities in NIF activities for use Navy-wide as alternate sources of supply for commercially unavailable parts. The estimated completion date for construction of the RTIF is 1989. The RAMP systems are expected to be operational within that facility in 1991. [Houts, 1986]

Current plans envision a RAMP SMP facility "capable of producing up to 15,000 parts ordered in an average lot size of four." [AMRC-A, 1988] It is important to note, however, that at the time of this writing the RAMP System is still under development. Therefore, almost all aspects of the project, from the technology utilized to the scope of operations, are subject to change.

This thesis addresses only the RAMP SMP facility and its specific components as described in the latest "Type B Specifications." Since project specifications are not finalized at this time, the RAMP SMP description contained in Part B of Chapter II represents only a "best guess" projection of the facility's final components and applications. The description is adequate, however, to serve as a model for Navy-run automated manufacturing facilities and is representative of current automated manufacturing technology. Therefore, it can be used to analyze NIF's adequacy for use with the RAMP SMP.

C. RESEARCH METHODOLOGY

Three research methodologies, Archival, Empirical, and Analytical, were used to develop and analyze the information presented in this thesis. The following paragraphs describe how each method was used.

1. Archival Research

Archival Research, in the form of a detailed literature review, was used to explore three major subject areas: automated manufacturing technology and related cost accounting issues; the Navy's RAMP project and the RAMP SMP facility; and the Navy Industrial Fund (NIF) Cost Accounting System. The sources of archival information for each subject area are detailed below.

Information on automated manufacturing technology and related cost accounting issues was drawn from an

extensive review of books, periodicals, and presentations published on the subject between 1984 and 1987.

Information on the RAMP project and the RAMP SMP facility was gleaned from a variety of Government publications, including "concept" and "talking" papers, periodicals, newsletters, research reports, program planning summaries and "Type B Specifications."

Information regarding the details of NIF cost accounting procedures was drawn from the Navy Comptroller Manual, NAVSO P-1000, Volume 5, the NAVSEA Navy Industrial Fund Financial Management Systems and Procedures Manual, NAVSEAINST 7600.27, and the NAVCOMPT self-taught correspondence course on NIF accounting procedures.

2. Empirical Research

Empirical Research was conducted in the form of field interviews. Personnel at the RAMP project office and the South Carolina Research Authority (SCRA) were interviewed to clarify issues related to the RAMP Project and the RAMP SMP facility. Personnel at a Naval Shipyard were interviewed to clarify NIF accounting procedures and RAMP accounting issues.

3. Analytical Research

Analytical Research, utilizing logic, inductive and deductive reasoning, was used to analyze data and develop conclusions.

D. THESIS ORGANIZATION

This thesis consists of six chapters designed to provide a framework for determining the adequacy of existing NIF accounting procedures for use with the RAMP SMP facility. Following the introduction in Chapter I, Chapter II discusses automated manufacturing technology, describes the RAMP System's operation, and details RAMP SMP components. Chapter III identifies and discusses cost accounting issues related to automated manufacturing. Chapter IV presents an overview of the Navy Industrial Fund Cost Accounting System. Using the information developed in Chapters II, III and IV, Chapter V analyzes NIF cost accounting procedures. Chapter VI presents the final conclusions.

II. <u>AUTOMATED MANUFACTURING TECHNOLOGY AND THE RAMP SMP FACILITY</u>

The introduction of computers into the manufacturing environment has brought on a manufacturing revolution. Advances in automation technology will soon yield fully automated factories which operate under the concept of computer integrated manufacturing (CIM). Current automated manufacturing technology encompasses a wide variety of industrial machines, computer hardware and computer software. These include numerical control machines, automated storage and retrieval systems, computer aided design, engineering and manufacturing, manufacturing resource planning, flexible manufacturing systems, and expert systems. CIM represents the combination of these separate components into a single, fully computer integrated manufacturing system. CIM and its component parts "bring fundamental changes to U.S. industry." [Lee, 1987]

Section A of this chapter provides a brief description of the automated manufacturing technology mentioned above. Section B describes, in terms of current technology, the Navy's RAMP SMP facility currently under development and construction in Charleston, South Carolina.

A. AUTOMATED MANUFACTURING TECHNOLOGY

In order to understand the impact of automation technology in the manufacturing environment, it is important to have a basic understanding of the technology itself. The following paragraphs describe the hardware and software components of automated manufacturing technology currently utilized as well as those anticipated in the near future.

1. Numerical Control (N/C) Machines

One of the simplest applications of computers for factory automation is the use of numerical control (N/C) machines. N/C machines are stand-alone, computer-programmed machine tools commonly used for milling, boring, drilling, grinding and similar industrial operations. Most N/C machines operate with one operator per machine, but some can operate unmanned. N/C machines can store multiple numerical control programs and can generally perform a number of operations. [Bennett et al., 1987]

2. Automated Storage/Retrieval Systems (AS/RS)

An automated storage/retrieval system (AS/RS) is an "automated system that stores and retrieves parts and products and can be integrated into a computerized manufacturing operation to keep accurate track of inventory and deliver parts at just the right moment." [Bose, 1984]

The primary benefits of AS/RS are increased speed and accuracy of inventory storage and retrieval. [Bennett et al., 1987]

3. CAD/CAM

Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) reflect the integration of computer and mechanical technology to facilitate the design, engineering and manufacturing processes. Sophisticated CAD/CAM software packages shorten the time between the birth of a new product idea and its production. [Bennett et al., 1987]

Computer aided design (CAD) refers to the use of sophisticated graphics software packages to develop, analyze, and modify product design. These design programs are used in conjunction with computer aided engineering (CAE) software. CAE consists of applications programs which provide engineers with quality, performance, cost and feasibility information based on the CAD designs. [Bennett et al., 1987; Lee, 1987]

Computer Aided Manufacturing (CAM) refers to automated manufacturing systems which utilize computers to plan, implement and control the production process. CAM includes a wide variety of systems ranging from those that generate plans but rely on human implementation and control to those that are essentially autonomous. [Bennett et al., 1987]

When used together, the computer sends CAD design information through CAE packages to verify quality, performance and cost factors and to ensure the feasibility of new product production on available equipment. Once CAE

verifies feasibility, the computer transmits required manufacturing information to the CAM system, which directs robots and other automated machinery to manufacture the product. [Lee, 1987] Benefits of CAD/CAM include:

- Increased productivity
- Enhanced design and product quality
- Shortened product cycle
- Three dimensional design simulation
- Reduced design/manufacturing costs
- Reduced training time. [Bennett et al., 1987]

4. <u>Flexible Manufacturing Systems (FMS)</u>

"An FMS is a computer controlled production system that produces a family of parts in a flexible manner." [Bennett et al., 1987] The primary benefit of FMS is its ability to quickly and easily switch from production of one product to manufacture of another. [Lee, 1987] A simple FMS might include only two machine tools and an automated materials handling system (MHS), both controlled by a computer. A more complex system might include robots for tool changing or parts replacement, automated storage and retrieval systems (AS/RS), automated washing, assembly, and inspection stations, and automated report generation. [Bennett et al., 1987]

The key elements of a flexible manufacturing system are machine tools, a materials handling system and a computer control system. "Each machine tool is a

numerically controlled machine with its own individual computer and is also linked to the FMS system computer." [Bennett et al., 1987] The material handling system transports each part between the various FMS stations. Both the machine tools and the material handling systems are controlled by the FMS system computer. "The computer downloads manufacturing programs to individual machine tools and schedules production for the machines. The amount of computer control is determined by the system's complexity." [Bennett et al., 1987]

Dilts and Russell cite 12 advantages of FMS over fixed manufacturing processes. The benefits derived from FMS include:

- Increased variety of outputs
- Increased product quality
- Reduced machine setup times
- No learning curve effect (at the machine level)
- Reduced leadtimes to supply customer demand
- Reduced direct labor cost
- Diminished work in process inventories
- Increased machine utilization
- Lower physical space requirements
- Reduced capital cost
- Increased ability to sustain production when a single machine or group of machines breaks down
- Quicker response to changes in demand. [Dilts et al., 1985]

5. Manufacturing Resource Planning (MRP-2)

Manufacturing Resource Planning (MRP-2) is a computerized system which provides an organization's various functional units with a common database for information necessary for resource control and optimal performance. Providing simulation capability, the MRP-2 system links strategic planning and management control by allowing comparison of various strategies with manufacturing capacities and changing conditions. [Lee, 1987] According to Mecimore and Weeks:

> The idea of managing material requirements based on anticipated needs has been understood and applied since production endeavors have been undertaken. What is new, however, is the ability to apply the concept to complex, large scale problems in rapidly changing environments. The commercial availability of high capacity computers and software programs provided the ability to use the MRP concept. [Mecimore et al., 1987]

MRP-2 takes management demand forecasts and generates manufacturing plans and master production schedules. It converts the master production schedule into time-phased, inventory-adjusted material requirements, plans and prints production and purchase orders, calculates human requirements, and checks its calculations against capacity. Its feedback capabilities allow the system to update itself and make adjustments as necessary. [Lee, 1987]

6. Expert Systems

Expert systems are sophisticated software packages which attempt to duplicate the decision making processes of human experts by applying human reasoning processes, rules

of logic and rules of thumb to database information. Expert systems incorporate qualitative as well as quantitative information into the decision making process. Because of their ability to simulate human decision making processes, expert systems are key to integrating the computer-driven activities discussed. They facilitate the removal of the "human bridges" required in non-computer integrated manufacturing processes by performing the decision making tasks formerly done by human experts. [Lee, 1987]

7. Computer Integrated Manufacturing (CIM)

CIM is the ultimate model of factory automation. CIM integrates numerical control machines, automated storage/retrieval systems, computer aided design, computer aided engineering, computer aided manufacturing, flexible manufacturing systems, management resource planning, and expert systems. The result is a manufacturing process which does "not require human bridges to link isolated work stations. The manufacturer's production process will be controlled entirely through a computer network." [Lee, 1987] From the birth of an idea through concept development, design, engineering, manufacturing and shipment, CIM automation directs and coordinates all stages of the process.

B. AUTOMATED MANUFACTURING TECHNOLOGY INCORPORATED IN THE RAMP PROJECT

Chapter I introduced the RAMP project's philosophy and outlined its missions and objectives. Section A of this chapter introduced the generic components of automated manufacturing systems and the concepts of Computer Integrated Manufacturing (CIM) and Flexible Manufacturing Systems (FMS). The RAMP SMP facility is comprised of a mixture of manual, mechanical, automated and fully computer integrated manufacturing equipment and processes. Because RAMP SMP incorporates both manual and computerized processes, and since it is not a fully computer integrated facility, it most closely fits the description of an FMS.

This section focuses on the RAMP SMP facility itself and addresses the specific manufacturing processes and technology to be used in the facility. Following an operational overview of the RAMP SMP, the facility and its components are discussed in a "layered" sequence, beginning with the most complex system elements and continuing to the least complex elements, the individual equipment components. Specifically, the overview is followed by a discussion of RAMP SMP's five functional components, internal and external interface requirements, internal control systems, peripherals and software, and equipment requirements.

The RAMP SMP facility is not scheduled to be completed and in operation until 1991. However, the descriptions of the system's components, its operation and its operational

relationships, with the exception of the operational overview, are written as if the facility were complete and in full operation.

1. RAMP SMP Operational Overview

As stated in Chapter I, the RAMP SMP's mission is to increase fleet readiness by reducing the production leadtime of parts, assemblies and equipment that are not readily available, i.e., to produce parts on demand (POD). The following scenario provides an overview of how the RAMP SMP functions to fulfill its mission. The Appendix provides a more detailed description of how the process might work.

Under the RAMP SMP concept, commercially unavailable parts are pre-screened, identified as RAMP candidates, and coded as RAMP items in the Inventory Control Point's (ICP) files. Drawings, blueprints, and other technical data for the part are converted into a digital electronic format known as electronic parts technical data (EPTD). When a RAMP item is requisitioned, the requisition is passed to the ICP who electronically transmits the requisition and the related EPTD to the RAMP facility. The RAMP computers then conduct process planning, develop equipment, operator, testing and inspection instructions, plan resources required, schedule production and direct the manufacturing process. Once the part is completed, RAMP personnel package and ship it to the customer. The entire process is expected to take less than 30 days.

2. <u>RAMP SMP Functional Components</u>

The computer system "provides the capability to plan, initiate, monitor, audit, communicate between, control, and perform the RAMP SMP activities in order to perform the functions and meet the performance parameters" required. [AMRC-A, 1988] The system consists of five functional components: Production and Inventory Control, Manufacturing, Manufacturing Engineering, Quality, and Information Management and Communications. [AMRC-A, 1988] Although each of the five functional components was discussed briefly in the operational overview, the following descriptions provide a more complete understanding of their purpose and their interaction with other components.

a. Production and Inventory Control Function

The Production and Inventory Control Function is the primary channel for sending parts orders and order status information between the RAMP SMP and the Navy ordering activity. Production and Inventory Control receives Electronic Parts Technical Data (EPTD) and order data from the ordering activity, forwards electronic job data to the Manufacturing Engineering function and part order administrative data to the Manufacturing function. [AMRC-A, 1988] This component contains four basic sub-functions: Capacity Requirements Planning, Production Control, Order Entry, and Material Inventory Management. Table 2-1 lists the Production and Inventory Control

subfunctions and the functional responsibilities within each subfunction.

TABLE 2-1

SUB-FUNCTIONS OF THE PRODUCTION AND INVENTORY CONTROL FUNCTION

1. Capacity Requirements Planning
   * Check for Capacity Problem
   * Determine Capacity Availability
2. Production Control
   * Create Shop Work Order
   * Request Material Reservation
   * Sequence Shop Work Orders
   * Determine Shop Work Order Release
   * Release to Customer
3. Order Entry
   * Determine Order to Order Inquiry Request
   * Determine Order Status
   * Initiate Order
   * Manage Initiate Order
   * Extract Bill of Material Data and Check
   * Convert to Native CAD Format and Check
   * Extract Order Administrative Data and Check
4. Material Inventory Management
   * Manage Material Requisitions
   * Check Inventory
   * Obtain Material for Order (Not Stocked)
   * Manage Inventory
   * Manage Pre-Provisioned Inventory
   * Determine Long Lead Time Items
   * Determine Pre-Provisioned Candidates and Generate Material Requisitions.

Source: [AMRC-E, 1987]

b. Manufacturing Function

The Manufacturing Function receives the shop order data from Production and Inventory Control and sends instructions to the production equipment. It receives activity and status reports back from the production equipment during production which are used to initiate information flow to and between other functional components. [AMRC-A, 1988] The Manufacturing System encompasses three basic subfunctions, Schedule Shop Resources, Control Shop Floor, and Monitor Shop Floor. Table 2-2 lists the Manufacturing System subfunctions and the functional responsibilities within each subfunction.

c. Manufacturing Engineering Function

The Manufacturing Engineering Function "determines process planning, shop equipment instructions, operator instructions, inspection and testing instructions" and related engineering functions. [AMRC-A, 1988] It receives the electronic job data from Production and Inventory Control and determines if a job process plan already exists for the part. If the plan exists, it uses the existing plan. If a job process plan does not exist for the part, it selects a plan from the same part family to be used as a basis for the development of the new part's process plan. Process planning personnel then utilize automated systems to create a new process plan. Furthermore, this function generates tool fixture and raw material

TABLE 2-2

SUB-FUNCTIONS OF THE MANUFACTURING FUNCTION

1. Manufacturing
   * Schedule Shop Resources
   * Extract Workstation Operations
   * Assign Equipment
   * Sequence Operations
2. Control Shop Floor
   * Production Equipment Control
   * Verify Tool Availability for Palletized Part
   * Verify Pallet and Tooling Delivery
   * Execute Production Task
   * Tooling Control
   * Manage Tool Assembly
   * Determine Next Preset Task
   * Tool Assembly
   * Preset Tools
   * Kit Assembled Tools
   * Determine Cause of Returned Tools
   * Update Tool Location
   * Disassemble Tool Assemblies
   * Manage Tool Crib
   * Issue Tool
   * Requisition Tool
   * Receive Tools
   * Rework Tool
   * Setup Area Control
   * Determine Next Setup Task
   * Check for Fixturing Availability
   * Generate Pallet Routing
   * Execute Part Setup
   * Determine Fixture Disposition
   * Execute Fixture Teardown
   * Manage Fixturing
   * Transportation Control
   * Determine Next Transportation Task
   * Execute Transportation Task
3. Monitor Shop Floor
   * Collect Data
   * Reduce Data
   * Update Data Stores
   * Determine Maintenance Requirements
   * Manage Preventive Maintenance
   * Manage Outage Maintenance

Source: [AMRC-E, 1987]

requirements. [AMRC-A, 1988] Manufacturing Engineering sub-functions are listed in Table 2-3.

TABLE 2-3

SUB-FUNCTIONS OF THE MANUFACTURING ENGINEERING FUNCTION

1. Check for Repeat Parts
2. Code and Classify Part
3. Select Similar Process Plan
4. Revise Process Plan
    * Insert Operations
    * Estimate Processing Times
    * Review Capacity Exceptions
5. Determine Stock Requirements
6. Generate Detailed Instructions
    * Manage Instruction Generation
    * Select Fixturing
    * Select Tooling
    * Select Required Tool from Library
    * Determine Disposition of Tool Exceptions
    * Determine Tool Configuration
    * Generate New Tool Configuration
    * Code Program
    * Verify Cutter Path
    * Post Process

Source: [AMRC-E, 1987]

d. Quality Function

The Quality Function determines component material requirements for each part. It generates quality reports from the parts quality data received from

Manufacturing, and it generates quality records. Quality also assures proper equipment calibration and system personnel certification. [AMRC-A, 1988] The Quality sub-functions include:

1. Generate Final Inspection Instructions
2. Determine Disposition of Quarantined Parts
3. Analyze and Report Quality Data
4. Assemble Part Pedigree
5. Validate Part Manufacture. [AMRC-E, 1987]

e. Information Management and Communication Function

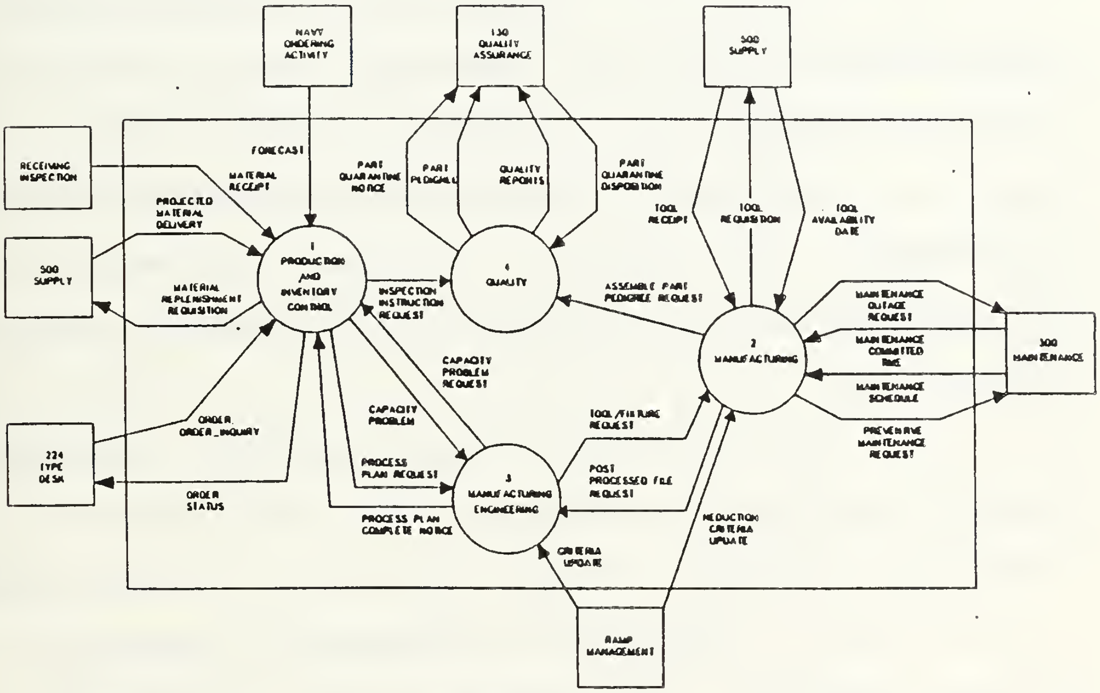
The Information Management and Communication Function supports and links the other four functional components with each other. It also provides the interface between the RAMP SMP, the Navy Industrial Fund (NIF) activity, and other outside activities by providing basic communications, data transfer, and database services. Information Management and Communication acts as the shell under which the other four functional components operate. [AMRC-A, 1988]

3. RAMP SMP System Interfaces

Since the RAMP SMP does not exist in a vacuum it must interface with outside activities. Five NIF activity functions are linked to the RAMP SMP by data transfer. The five activities are Supply, Central Tool, Supply/Tool Management, Equipment and Facility Maintenance, Payroll, and Quality Services. The system is also electronically linked

to three other types of external organizations: Navy ordering activities, tooling vendors, and cognizant technical authorities. [AMRC-D, 1988]

Figure 2-1 summarizes RAMP SMP-NIF internal and external interfaces.



Source: [AMRC-B, 1988]

Figure 2-1 Summary of RAMP SMP-CNSY Internal and External Interfaces

4. RAMP SMP Control System

The RAMP SMP control system is comprised of hierarchical levels implemented through a number of subsystems. There are three basic levels of control: Cell Level Control, Workstation Level Control and Device Level Control. [AMRC-C, 1988]

a. Cell Level Control

At the Cell Control Level, each cell is composed of a Cell Processor, a Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) subsystem and a Computer Aided Process Planning (CAPP) subsystem. [AMRC-C, 1988]

The Cell Processor is the computer which governs workstation operations. It sends instructions to and integrates the operations of all components within the workstation.

The CAD/CAM subsystem provides a full-featured CAD/CAM application package with high resolution color graphics and rapid response capabilities. It supports a multi-tasking environment, simultaneous users and a high volume workload. It features system development tools, including compilers, and provides inter-program communication. [AMRC-C, 1988]

The CAPP subsystem supports simultaneous users with a full CAPP application system in a multi-tasking environment. It too provides interprogram communication and system development tools. [AMRC-C, 1988]

b. Workstation Level Control

The Workstation Control Level, which works at the same level as the CAD/CAM and CAPP subsystems, supervises the operation of and provides the operator interface with equipment on the factory floor. Based on instructions from the Cell Processors, Workstations control the manufacturing equipment. Each workstation could control a variety of different types of equipment. [AMRC-C, 1988]

c. Device Level Control

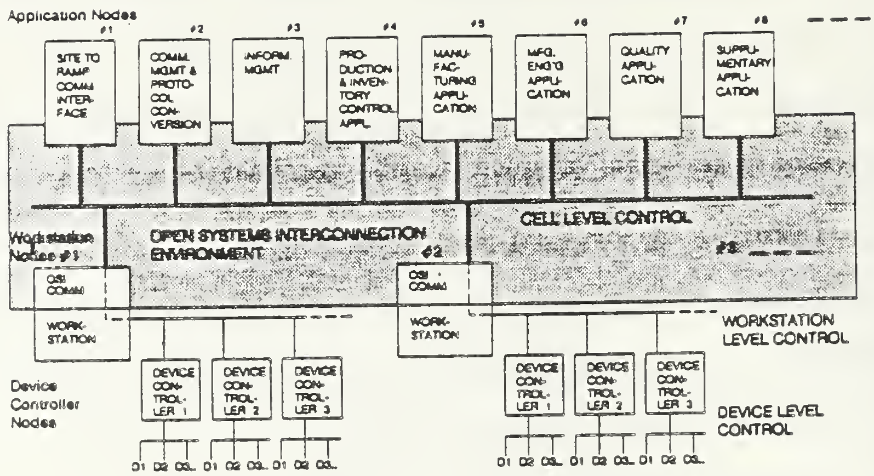
Device Level Control consists of equipment controllers which provide numeric machine control and inter-program communication capabilities. The controllers receive input from and transmit information to higher level computers without interrupting the manufacturing process, and provide for manual input/override of operating instructions. [AMRC-C, 1988]

Figure 2-2 provides an overview of the RAMP SMP Control System.

5. <u>RAMP SMP Peripherals and Software</u>

RAMP SMP utilizes off-the-shelf peripherals at the Cell and Workstation levels. A combination of off-the-shelf and internally developed software are used. [AMRC-A, 1988]

Operating System software, Applications software, and Network Management Systems software are "off-the-shelf," as are the software packages utilized in the implementation of the Production and Inventory Control, Manufacturing,



Source: [AMRC-C, 1988]

Figure 2-2 RAMP SMP Control System

Manufacturing Engineering, and Quality functions. All Interface and Control software is internally developed. The off-the-shelf software and "site interface software modules" are fully integrated. [AMRC-A, 1988]

6. <u>RAMP SMP Manufacturing Equipment</u>

The RAMP SMP utilizes a Free-Flow, Multi-Machine manufacturing concept organized to facilitate production of a variety of parts. The facility is designed to manufacture small cylindrical and prismatic mechanical parts. Figure 2-3 is a RAMP SMP floor plan and illustrates the Free Flow concept. [AMRC-C, 1988] Table 2-4 provides a list of part types suited for manufacture in the facility, and Table 2-5

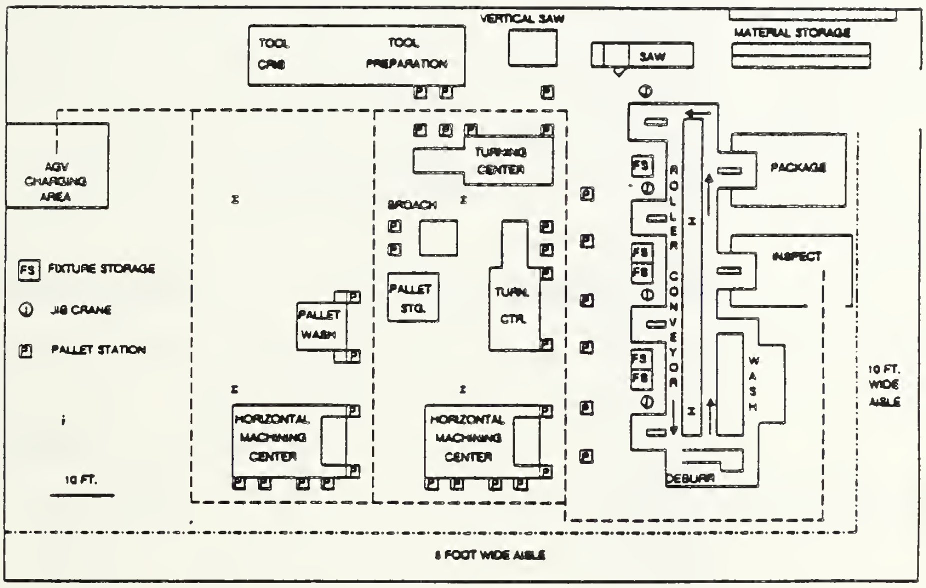


Figure 2-3 RAMP SMP Free Flow Concept

TABLE 2-4

PARTS TYPES

Adapter
Angle, leg
Ball
Bearing
Body
Bolt
Bonnet
Boss
Bracket
Bushing
Butt, end
Cam
Cap
Case, gear
Collar
Connector
Coupling
Elbow
Fitting
Gland
Guide
Handle
Nipple
Nozzle
Nut
Pin
Plate, backing
Plug
Prismatic Blank
Prismatic Flange
Prismatic Pad
Reducer
Ring
Roller
Round Blank
Round Flange
Round Pad
Shaft
Sleeve
Socket
Socket end
Spacer
Stem
Stud
Support
Tailpiece
Tee

TABLE 2-4 (CONTINUED)

Threadpiece
Union
Valve
Washer
"Y" Branch

Source: [AMRC-C, 1988]

TABLE 2-5

SIZE AND WEIGHT CONSTRAINTS FOR RAMP SMP MANUFACTURED PARTS

CYLINDRICAL PARTS	PRISMATIC PARTS
Maximum Diameter: 12"	Maximum: L24" x W16" x H21"
Maximum Length: 10 times diameter up to 24"	
Minimum Diameter: 3/8"	Minimum: L2" x W2" x H1/2"
Minimum Length: 1/4"	
Maximum Weight: 300 lbs.	Maximum Weight: 300 lbs.

Source: [AMRC-C, 1988]

delineates the size and weight constraints imposed on those parts.

The facility processes a wide range of materials which includes steel, aluminum, numerous other metals and alloys and industrial plastics. No special cutting tools beyond those available commercially are required. [AMRC-C, 1988]

The RAMP SMP utilizes nine basic manufacturing operations. They include Sawing, Turning, Milling, Drilling, Tapping, Broaching, Boring, Deburring, and Washing. Five operations, Turning, Milling, Boring, Facing, and Drilling are considered "major demand operations" and incorporate state-of-the-art technology. [AMRC-C, 1988] Other operations are completed by manual or other processes which are not fully computer integrated.

The equipment used in the RAMP SMP facility is comprised of a mixture of manual, mechanical, automated, and fully computer integrated equipment. The following listing provides a description of the equipment installed in the facility and the degree of automation involved with each type of equipment.

1. Fully Automated/Computer Integrated Equipment:

   * Automated Guided Vehicle (AGV) Material Handling System
   * Conveyor Material Handling System
   * Large Numeric Control Horizontal Machining Center
   * Large Turning Center
   * Numeric Control Coordinate Measuring Machine
   * Pallet Pickup and Delivery System
   * Small Numeric Control Horizontal Machining Center
   * Small Turning Center
   * Equipment Controllers

2. Automated Equipment with Limited Computer Interface:

   * Palletized and Fixtured Part Cleaning Equipment

   * Tool Pre-setters

   * Free-Part Cleaning Equipment

3. Manual Equipment with Computer Interface (Delivery, Schedule, etc.):

   * Broaching Machine

   * Deburring Equipment

   * Fixture Equipment (Modular/Reusable)

   * Horizontal Bandsaw

4. Manual Equipment (no computer interface):

   * Forklift Truck

   * Large Drill Grinder

   * Small Drill Grinder

   * Vertical Band Saw

   * Miscellaneous Materials Handling Equipment

   * Packaging and Shipping Equipment

5. Miscellaneous Equipment:

   * Maintenance Tools and Equipment

   * Large Heavy Duty Storage Cabinets

   * Small Heavy Duty Storage Cabinets

   * Material Storage Racks. [AMRC-C, 1988]

C. SUMMARY

This chapter presented a general overview of the automated manufacturing technology in use today and that technology expected to be available in the near future. It

introduced the RAMP SMP facility, and it provided an overview of the facility's hardware and software components and its manufacturing processes and capabilities. The information in this chapter is important to aid the reader in understanding the accounting issues discussed in Chapter III and their impact on the Navy Industrial Fund (NIF) cost accounting system.

III. COST ACCOUNTING ISSUES FOR AUTOMATED MANUFACTURING

This chapter discusses the cost accounting issues which arise with the introduction of automated manufacturing techniques and the transition from a man-paced to a machine-paced manufacturing environment. The chapter begins with a discussion of the impact of automation on considerations of product cost, then follows with a discussion of issues regarding cost control, performance measurement, information requirements, capital acquisition, and quality control.

As the cost of employee wages and benefits have increased, management attention has focused on ways to decrease direct labor cost as a percentage of total cost. Flexible manufacturing systems (FMS) meet that objective. With FMSs, as equipment replaces labor, direct labor costs have been significantly decreased and in come cases almost completely eliminated. [Dilts et al., 1985] In many automated manufacturing processes, direct labor accounts for only eight to 12 percent of total cost. [Brimson, 1986] This decrease in the direct labor component of the manufacturing process is at the root of many of the following cost accounting issues.

A. PRODUCT COSTING

1. Direct vs. Indirect Cost

The effect of automation technology on the proportion of direct and indirect costs depends on the definition used for direct cost and the capabilities of the information system supporting the manufacturing process. "The determination of whether a cost is direct or indirect is often a matter of definition." [Brimson, 1986]

The traditional definition classifies direct cost as "the cost of any good or service that contributes to and is readily ascribable to product or service output," whereas an indirect cost is "a functional cost not attributed to the production of a specified good or service but to an activity associated with production generally." [Kohler, 1975] If the traditional definition of direct cost is applied in a machine-paced environment, the result is a decrease in direct cost and an increase in indirect cost as a more significant portion of total product cost becomes equipment related. [Brimson, 1986] Direct labor costs are decreased and factory overhead increases. As equipment costs increase, indirect labor cost also increases as a result of the addition of highly paid professional and specialized support staffs who manage and maintain the system. [Dilts et al., 1985] This shift from direct to indirect cost and the subsequent increase in the proportion of allocated cost blurs the once clear product cost picture. This requires

that the old definition of direct and indirect cost be reviewed. [Brimson, 1986]

Allen Seed suggests that, for the machine-paced environment,

> direct costs be defined as costs that can be assigned directly to a cost center or product irrespective of their behavioral characteristics. Indirect costs are those which must be allocated to cost centers or products. [Seed, 1984]

Seed states that under this definition, such costs as depreciation, maintenance of machine center equipment, and wages and fringe benefits of personnel who operate the machine center can be treated as direct costs. On the other hand, costs such as those for tool room equipment maintenance and wages and fringes for production scheduling and industrial engineering personnel should be treated as indirect. [Seed, 1984]

Coupled with the definitional change is the increased availability of shop-floor data brought on by the introduction of automation and the related computerized information systems such as local area networks (LAN) and automated parts tracking systems. As a result of these changes, many costs previously considered indirect in the man-paced environment can now be specifically identified to cost centers and may be treated as direct costs in the machine-paced environment. [Brimson, 1986] Therefore, automation results in an increase in the proportion of direct to indirect costs and more exact product costing.

Table 3-1 presents a listing of direct and indirect costs for both the man-paced and machine-paced environments under the revised definition for direct costs.

TABLE 3-1

DIRECT COSTS

	Man-Paced Environment	Machine- Environment
Direct labor	Direct	Direct
Material Handling Labor	Direct	*Eliminated
Quality Control Labor	Direct	Direct
Repairs and Maintenance	Direct	Direct
Overtime Premium	Direct	Direct
Payroll Taxes & Benefits	Direct	Direct
Energy	Direct	Direct
Operating Supplies	Direct	Direct
Supervision	Indirect	Largely Indirect
Building Occupancy	Indirect	Indirect
Insurance and Taxes	Indirect	Direct
Depreciation	Indirect	Direct

*Eliminated or reduced depending on the degree of automation in the MHS; treated as direct cost if only reduced.

Source: [Seed, 1986]

2. Allocation of Indirect Cost

Those indirect costs which remain in the automated environment still must be allocated for inclusion in the product cost. Historically, when direct labor was a large component of total manufacturing cost, overhead was primarily allocated on a direct labor basis. [Bennett et al., 1987] In the FMS environment, direct labor is no longer a major component of product cost. [Dilts et al., 1985] With the continued use of direct labor hours as an allocation base despite their insignificance in the FMS environment, management loses sight of the cause and effect relationship necessary for sound cost allocation. "The relationship between the basis of allocation and the indirect cost...becomes obscure." [Brimson, 1986]

Increasingly, manufacturers are using alternative bases for indirect cost allocation, such as materials, units of production, services rendered, or other non-labor bases. [Seed, 1984] Managers must utilize an appropriate allocation base which maintains the cause and effect relationship between the base and the cost object and accurately reflects the productive capacity of the FMS. [Bennett et al., 1987] Bennett, Hendricks, Keys and Rudnicki indicate that four of the most common allocation bases used in the automated environment are units of production, total time in the FMS, engineered machine hours, and actual machine hours. [Bennett et al., 1987]

Table 3-2 presents the advantages and disadvantages of these allocation bases.

TABLE 3-2

ADVANTAGES AND DISADVANTAGES OF POSSIBLE OVERHEAD BASES

Overhead Base	Advantages	Disadvantages
Units of Production	Simplicity; ease of use	Parts machined in the FMS often are not homogeneous and require different operations
Total Time in FMS	Reflects productive capacity of entire FMS	Difficult to measure and record
Engineered Machine Hours	Reflects machine time that should be used; readily available	Does not represent actual machine time or total time used in FMS
Actual Machine Hours	Measures use of productive capacity of machine tools; can be recorded by machine computer or FMS central computer	Includes inefficiencies in operation of machine tools

Source: [Bennett et al., 1987]

3. Fixed vs. Variable Cost

Just as the nature of direct and indirect cost has changed with automation, so has the mixture of fixed and variable cost. Many components of manufacturing cost that were once considered variable are fixed in the automated

environment. Those costs which change in nature from variable to fixed are primarily labor related. The variable factors which remain are materials, energy, operating supplies and overtime premium. [Seed, 1986] Table 3-3 details the components of variable and fixed costs in both the man-paced and machine-paced environments.

TABLE 3-3

FIXED AND VARIABLE COSTS IN THE MAN-PACED AND MACHINE-PACED ENVIRONMENT

<u>Variable Costs Both Environments</u>

Materials
Energy
Operating Supplies
Overtime Premium

Variable Costs--Man-Paced Environment;
<u>Fixed Costs Machine-Paced Environment</u>

*Direct Labor Operations
*Labor Fringe Benefits
Set-up Labor
Material Handling Labor
Quality Control Labor
Repairs and Maintenance

<u>Fixed Costs Both Environments</u>

Supervision
Production Support Services
Building Occupancy
Insurance
Property Taxes
Depreciation--Machinery and Equipment

*Seed defines direct costs "as costs that can be assigned directly to a cost center or product irrespective of their behavioral characteristics...the wages and fringe benefits of the personnel who operate the machine center are a direct cost."

Source: [Seed, 1984]

With labor-related costs primarily fixed, variable costs as a percentage of total manufacturing cost is sharply decreased. [Lee, 1987] As a result, variable costing essentially means costing only on the basis of materials, energy and operating supply costs. Dilts argues that variable costing loses its meaning and full absorption costing becomes the only reasonable costing approach. [Dilts et al., 1985]

4. Learning Curve Effect

Another result of automation is the diminished impact of the learning curve effect on product cost. [Dilts et al., 1985] The learning curve effect refers to a decrease in product cost which occurs as workers become more familiar with a repetitive production process. As workers become more proficient over the course of a production run, labor hours required and production mistakes made are decreased, resulting in lower product cost. This decrease in cost has been shown to occur at a constant rate for each doubling of the production quantity. For instance, a production process that operates on a 90 percent learning curve and has an initial unit cost of $10.00, would be expected to produce the second unit for $9.00, the fourth unit for $8.10, the eighth unit for $7.29 and so forth for the length of the production run. [Lee, 1987]

Learning curves exist in the man-paced environment because of the prominence of direct labor in the

manufacturing process and because of man's ability to learn and improve upon performance through repetition. However, the learning curve is not significant at the machine level of an FMS. In an FMS, machines are programmed with the appropriate manufacturing instructions and are directed in carrying out the production process by a controlling computer. "Once the system has learned the operation method, it will repeat the task identically each time. The reduction of labor hours," which is the primary impetus of the learning curve effect, is no longer important. [Lee, 1987]

B. COST CONTROL

The move to an automated manufacturing environment shifts the primary responsibility for cost control away from line supervisors and onto manufacturing technologists. Since automation increases fixed and reduces variable cost, production managers become responsible for managing output rather than cost; however, scheduling, breakdowns and work stoppages are still beyond their control. As a result,

> control, and the focus of control reporting, shifts from the plant floor to the engineering, planning, scheduling and maintenance functions...investment and inventory management decisions become the focal point of the control system. [Seed, 1984]

The FMS technologist becomes the cost controller.

As responsibility for cost control shifts from the production manager to the technologist, cost control becomes a process of eliminating "waste" from the manufacturing

process. In this context, waste refers to nonvalue-added activities. Nonvalue-added activities are those which are a part of the manufacturing process, but do not add value to the product. [McIlhattan, 1987]

Traditional cost accounting has focused on capturing costs resulting from the manufacturing process. In an FMS, the emphasis shifts to identifying the true causes of cost, the "cost drivers." Once the system's cost drivers are identified, technologists and accountants can work together to eliminate product design and manufacturing process inefficiencies and nonvalue-added activities which drive up product cost but do not add value. [McIlhattan, 1987] Table 3-4 is a list of potential cost drivers.

While manufacturing technologists become the primary cost controllers in an FMS, the production supervisor still controls such production elements as direct materials, indirect materials, tooling, set-up labor, off-line inspection costs and others. To facilitate supervisor control, these costs must be made clearly visible. "This may be achieved by the use of flexible budgets at the FMS level that clearly delineate controllable and uncontrollable cost," and performance reports which compare actual costs with budgeted controllable costs. [Bennett et al., 1987]

C. PERFORMANCE MEASUREMENT

As is true with most other aspects of traditional cost accounting, performance measurement in the traditional

TABLE 3-4

POTENTIAL COST DRIVERS

Number of Labor Transactions
Number of Material Moves
Number of Total Part Numbers
Number of Parts received in a month
Number of Part Numbers in an average product
Number of Products
Average Number of Options
Number of Schedule Changes
Number of Accessories
Number of Vendors
Number of Units Scrapped
Number of Engineering Change Notices
Number of Process Changes
Number of Units Reworked
Number of Direct Labor Employees
Number of New Parts Introduced

Source: [McIlhattan, 1987]

environment was developed when direct labor cost was a major component of total product cost. As a result, many traditional performance measures focus on direct labor hours, direct labor cost, and labor efficiency. Since direct labor is an insignificant cost in the FMS environment, these performance measurements are inappropriate, as are direct labor productivity, machine utilization and standard versus actual performance. [Howell et al., 1987; Bennett et al., 1987] Focusing on labor or machine utilization as measures of performance can motivate managers

to produce more product and build larger inventories than are necessary. Automation and statistical process control create very reliable, consistent manufacturing processes, and, as a result, standard costing becomes less relevant because variances are minimized. [Howell et al., 1987] Furthermore, "emphasizing performance to standard gives priority to output at the expense of quality...once standards have been met people feel they have 'arrived'" and no further improvement is required. [McIlhattan, 1987]

In the new manufacturing environment, measurement of individual performance becomes less important. Performance measurement should be done at the manufacturing cell level. In an FMS, machine downtime and individual worker productivity cannot be used as performance measures. Since the system is fully integrated and computer controlled, individual and machine performance are limited to following the pre-programmed flow of the process. As a result, there are times when specific machines and individuals are not supposed to work. "System productivity is affected very little by the varying degrees of individual employee ability once the employees acquire the proficiency needed to operate in that setting." [Lee, 1987]

In the new manufacturing environment, management accountants and manufacturers must work together to develop new, more appropriate ways to monitor performance and reduce

costs. New performance measures should be multi-dimensional; they should be simple and easy to understand, and they should include financial and non-financial indicators which identify cost drivers as well as focus on quality. [McIlhattan, 1987]

Table 3-5 lists traditional performance measures as well as possible measures to be used in the machine-paced environment.

D. INFORMATION REQUIREMENTS

Introducing advanced automated techniques into the manufacturing process changes the nature of information requirements and dictates a review of organizational management information systems (MIS). The importance of and dependency on computerized information increases as more advanced technology is added. Manual information systems are inadequate because of their questionable reliability, their need for continuous review and correction, and their failure to provide timely information. Manual and batch type systems must both be replaced by real-time computerized information systems, because in an FMS, the availability of instantaneous feedback and real-time information is essential for quality and process control, product costing and performance measurement. [Brimson, 1986]

TABLE 3-5

PERFORMANCE MEASURES

Man-Paced Environment	Machine-Paced Environment
Direct Labor: Efficiency, Utilization, Productivity	Total Head Count Productivity -Output--Total Head count (direct, indirect, administrative personnel)
Machine Utilization	Return on Net Assets
Inventory Turnover or Months on Hand	Days of Inventory
Cost Variances	Product Cost; especially relative to competitor's cost
Individual Incentives	Group Incentives
Performance to Schedule	Customer Service
Promotion based on Seniority	Promotion Based upon increased knowledge and capability
	Ideas Generated
	Ideas Implemented
	Lead time by product/product family
	Set-up reduction
	Number of customer complaints
	Response time to customer feedback
	Machine Availability
	Cost of Quality

Source: [Huge et al., 1986]

E. CAPITAL ACQUISITION

Because many of the benefits of flexible manufacturing systems are hard to quantify, capital budgeting decisions involving acquisition of an FMS are made more difficult. [Brimson, 1986] Although application of standard discounted cash flow (DCF)/net present value (NPV) capital budgeting techniques often fail to justify investment in FMS technology, the problem may be with application of the technique rather than with the investment itself. Standard capital budgeting techniques must be modified to incorporate the special circumstances related to FMS acquisition. [Kaplan, 1986]

Two major problems are inherent in standard application of DCF techniques: hurdle rates are sometimes set arbitrarily high, and standard DCF techniques focus too narrowly on labor, energy or materials savings and overlook those savings that are less common or more difficult to quantify. [Kaplan, 1986]

One of the major benefits of FMS technology is its flexibility. Because of its ability to change processes by changing programming, an FMS can adapt to changing markets and product evolution. Its useful life is extended to manufacture successive generations of products, well beyond the life span of traditional manufacturing investments. "Companies frequently set arbitrarily high hurdle rates for evaluating new investment projects." [Kaplan, 1986] An

FMS's increased life span, coupled with arbitrarily high discount rates, penalizes FMS investments by understating the FMS's cash flow contributions in later years. This unfairly makes FMS investments appear unfavorable when compared to shorter term investments. By utilizing "a discount rate based on the project's opportunity cost of capital," this problem can be minimized, because the lower discount rate would enhance the value of cash flows earned in later years and would increase the overall Net Present Value of the FMS investment. [Kaplan, 1986]

Broadening the focus of the standard DCF technique to include quantifiable FMS benefits can help solve the second problem. Some of the savings to be realized from acquisition of FMS, such as reduced work in process and finished goods inventories, reduced floor space requirements, and reduced spoilage, scrap and quality assurance costs are easily quantified and should be included in the capital budgeting process. Many other benefits, such as flexibility, faster response time to changes in demand, and shorter lead and throughput times, are harder to quantify, but they should not be considered of zero value or left out of the investment decision. [Kaplan, 1986]

The DCF capital budgeting technique which follows is based on procedures recommended by Robert Kaplan for use with FMS investments; it should be carried out as follows:

1. Select a hurdle rate representative of the opportunity cost of capital.

2. Begin the DCF analysis by including common costs and benefits.

3. Estimate and include in the analysis cash flows from FMS related benefits that can be readily quantified with a satisfactory degree of confidence.

4. Compute the NPV and determine if it is positive or negative.

5. If the NPV is positive, consider approving the investment. If NPV is negative continue analysis.

6. Compute how much <u>annual</u> cash flow must be increased before a positive NPV is achieved.

7. Decide if the intangible benefits to be derived from investing in the FMS are at least as much as the amount cash flow must be increased.

8. If the answer to the above question is yes, then consider making the investment. If the answer is no, then the investment probably should not be made.

By reversing the process and estimating how large the benefits must be to justify the investment, DCF techniques will provide sound capital budgeting criteria. [Kaplan, 1986]

F. QUALITY CONTROL

Higher quality output is one of the major objectives of flexible manufacturing systems. [Howell et al., 1987] FMSs make it possible to manufacture "products with higher levels of quality...because of the inherent consistency of automation and improvements in computer aided engineering." [Brimson, 1986]

In man-paced systems, quality assurance focuses on <u>verifying</u> that finished products meet required quality

standards. The quality assurance effort is "after-the-fact." Flexible manufacturing systems, however, can build quality checks into the system for each manufacturing stage in order to ensure that the finished product conforms to standard. [Dilts et al., 1985] When the system detects a problem, the entire production process can be shut down until the problem is corrected. The responsibility for quality control shifts from the quality control organization to the production function, and the focus of production shifts from gross output to quality output. As a result, spoilage and shrinkage are minimized. "Because of the accuracy and repeatability of the system, the rate of spoilage and shrinkage are known with near certainty, and the need to calculate materials mix variances is marginal." [Dilts et al., 1985]

As a result of the change in manufacturing technology, accountants must develop and implement new measures to monitor quality cost and performance. Howell and Soucy recommend four areas of focus: customer acceptance, in-process audit, vendor quality/incoming inspection, and cost of non-conformance. [Howell et al., 1987]

Customer acceptance involves measuring customer complaints, field service expenses, and other reflections of customer satisfaction. In-process audit refers to the random measurement of quality at specific points in the manufacturing process as described above. Vendor quality

and incoming inspection refer to rating suppliers on the quality of the products they provide as well as on delivery and price, and inspecting incoming material to ensure that only quality raw materials are introduced into the manufacturing process. The final area of focus, cost of nonconformance, suggests aggregating all of the costs of producing non-quality products so that the real cost of quality related problems can be determined. [Howell et al., 1987]

G. SUMMARY

Each of the accounting issues listed above exists because of the introduction of automation into the manufacturing process. These issues apply not only to cost accounting in private manufacturing concerns, but also will affect accounting for the RAMP SMP facility. Therefore, these issues and their effect on Navy Industrial Fund cost accounting are the subject of the analysis conducted in Chapter V.

IV. THE NAVY INDUSTRIAL FUND (NIF) ACCOUNTING SYSTEM

A. INTRODUCTION

The Navy Industrial Fund (NIF) is a revolving fund established by Congress in 1949 to help Navy commercial/industrial activities function in a more efficient and businesslike manner. Commercial/industrial activities are defined as those where a buyer-seller relationship exists. NIF was intended to free these activities from total dependence on the annual appropriation process by providing working capital, called the NIF Corpus, to finance operations from the time that specific work is begun to the time that payment is received from the customer. Unlike private industry, which is driven by the profit motive, NIF seeks only to break even. Therefore, NIF operations require strict cost control to prevent potential losses. This cost control is achieved through the Navy Industrial Fund Accounting System, also referred to simply as NIF. [NAVCOMPT-A, 1985]

NIF has three important features which encourage better management and promote an environment similar to that found in private industry:

> First, a contractual relationship is established between the customer and the activity requiring the activity to define the task and accurately estimate the costs. This enables the customer to prepare a better and more realistic appropriation budget request from Congress to pay for the work. The customers are then able to order

only the specific items or services they need. The customers are billed by the NIF activity and proceeds are a reimbursement for costs incurred.

Second, the cost accounting system relates costs to a specific job. This is essential for maximum control of costs, developing standard pricing, and projecting accurate cost budgets.

Third, the revolving fund provides additional flexibility by being free of the Congressional appropriation cycle. Therefore, the Industrial Fund provides for responsible and efficient local management. [NAVCOMPT-A, 1985]

As a result of these features, the NIF accounting system provides nine advantages to Industrial Fund activities. Table 4-1 lists those advantages.

The Navy Comptroller Manual, Volume 5 (NAVCOMPT, Vol. 5), entitled "Navy and Marine Corps Industrial Funds," promulgates NIF accounting procedures. The procedures for operating NIF are different depending on the type of activity involved. Therefore, the appendices to Volume 5 give general guidance while Parent Commands and individual activities issue more detailed, standardized NIF operating procedures for each type of NIF activity. [NAVCOMPT-A, 1985; NAVCOMPT-B, undated]

Since current plans will result in operation of the RAMP SMP facility in a Naval Shipyard environment, this description of the NIF system will focus on shipyard procedures.

TABLE 4-1

ADVANTAGES OF THE NIF ACCOUNTING SYSTEM

NIF accounting provides the following advantages to Industrial Fund activities:

* A business-type budgeting and accounting system permitting tailor-made adaptations
* A basic, stable accounting system
* Authority to start emergency work on a sponsor's orders prior to receipt of funds
* A means to finance and carry inventory of non-standard material
* The convenience of using working capital for initially charging all costs
* A method for developing total costs of each task or project, including overhead
* A means for producing management cost data by job order, cost center or other organizational breakdown
* Assistance for management to better control money, man-power, material and facility resources
* A method for accrual of leave and fringe benefits cost.

Source: [NAVCOMPT-A, 1985]

B. OVERVIEW

As previously stated, NIF activities maintain a buyer-seller relationship with and produce goods or services for their customers. The NIF cycle operates as follows:

> The customer sends a reimbursable order for products or services to a NIF activity. The NIF activity accepts the order and commences work initially charging all costs to working capital (NIF Corpus) including project related labor and material, other direct costs, production expense, and general and administrative expense. Upon completion, the product or service is received by the

customer who is billed for the cost of that product or service. Reimbursements are made to NIF working capital for that effort and the cycle is completed. [NAVCOMPT-A, 1985]

Figure 4-1 illustrates the NIF cycle.

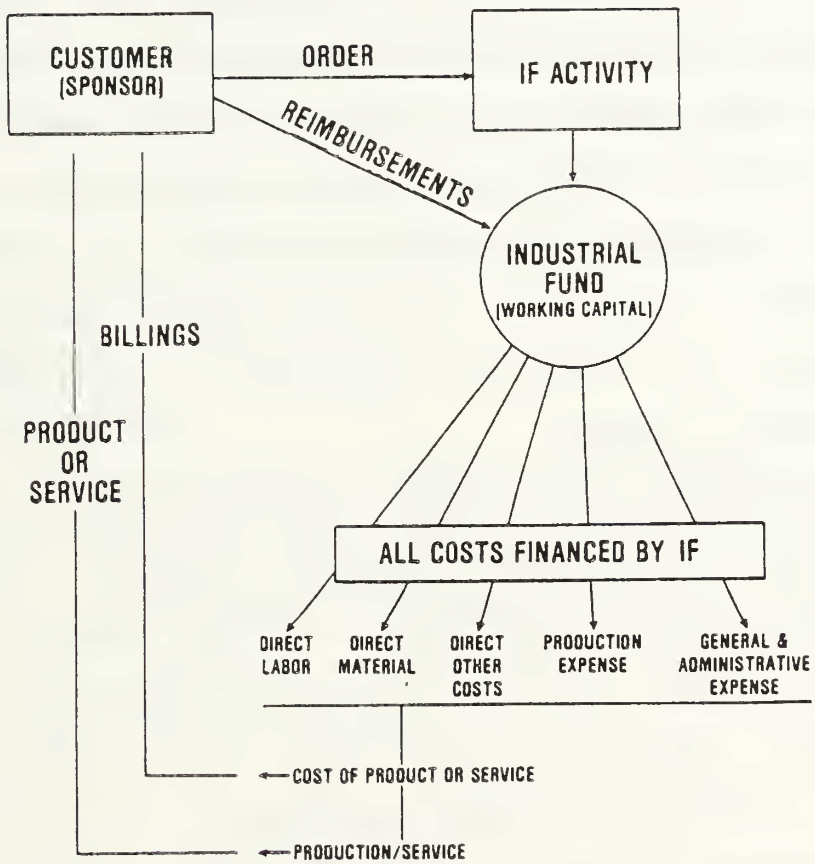


Figure 4-1 The NIF Cycle

The accounting principles and procedures for the NIF system are similar to those used in the private sector. NIF uses a standard double entry, accrual basis accounting system where expenses are recorded in the period incurred

and revenue is recognized in the period earned regardless of when cash is paid or received. NIF maintains a chart of accounts for assets, liabilities, capital, expenses and revenues which make up the general ledger. Transactions are recorded in detail to a journal and posted appropriately to the chart of accounts. The various asset and liability accounts are summarized in the Statement of Financial Condition. The expense and revenue accounts are summarized in the Statement of Revenue and Cost. The profit or loss shown on the Statement of Revenue and Cost is reflected as an increase or decrease to the capital accounts in the Statement of Financial Condition. [NAVCOMPT-A, 1985; NAVCOMPT-B, undated]

The number of accounts maintained by a specific NIF activity is dependent on many factors. However, the NAVCOMPT Manual prescribes a uniform chart of numbered general ledger accounts in order to ensure the ability to aggregate similar financial data at succeeding levels of command and to facilitate development of uniform Electronic Data Processing (EDP) financial systems. [NAVCOMPT-A, 1985; NAVCOMPT-B, undated]

In 1987, a NAVCOMPT NOTICE was issue which detailed a standard, uniform chart of accounts to be used throughout the Navy for all appropriated funds. Implementation of this uniform chart of accounts has begun at the Department of the Navy level, and will continue from the top down over the

next several years. This change is not expected to impact the activity level until approximately 1992. Therefore, while all account numbers and references to the chart of accounts relate to those that exist in FY-88, the reader should be aware that changes are pending in the future.

NIF uses an accrual-type job order cost system which provides cost accounting information necessary to determine product cost at the job level. NIF also uses the full absorbtion costing method, which recognizes both fixed and variable costs as elements of total product cost.

C. COST ACCOUNTING PROCEDURES

1. Cost Centers

For cost accounting purposes, NIF activities are divided into functional units known as cost centers. Cost centers are established at natural points for cost collection and overhead distribution. The nature of individual cost centers depends on the organization, but could range in size from an entire department to an individual shop. Each individual employee is assigned to one cost center only. [NAVCOMPT-A, 1985; NAVCOMPT-B, undated]

There are three types of cost centers, Production, General and Service. Production cost centers are those associated with performance of actual productive work. Their efforts are directly identifiable to specific jobs. General expense cost centers are those which provide support

services to the activity as a whole. Such cost centers might include the Comptroller Department, the Personnel Office, Security or other activity-wide support services and are considered to be overhead expenses. Service cost centers, such as manufacturing, transportation, or data processing are separate entities which perform all of their services on an inter-activity user charge basis. Such cost centers do not generate overhead or receive applied overhead from other cost centers. "One hundred percent of their costs are distributed to their customers on an identical user charge basis." [NAVCOMPT-A, 1985; NAVCOMPT-B, undated]

2. Types of Cost

Within the accounting system there are two basic types of cost, direct and indirect. Direct costs are those that can be directly linked with the final product or service. Indirect costs are those that cannot feasibly be linked to a final product or service and therefore must be allocated. The term indirect cost is synonymous with overhead. [NAVCOMPT-B, undated]

There are two types of overhead (indirect) costs, Production overhead and General and Administrative (G&A) overhead. Production overhead "includes those indirect costs that are identified to a direct (production) cost center." [NAVCOMPT-A, 1985] Examples of production overhead include production supervision, equipment maintenance labor and supplies and clerical support for production

functions. "General and administrative overhead costs are those that benefit the whole activity," such as security services, personnel services and executive salaries. [NAVCOMPT-A, 1985; NAVCOMPT-B, undated]

3. Elements of Cost and Expense

The elements of cost associated with production include labor, material, contractual services and others. [NAVCOMPT-A, 1985]

Labor costs consist of regular hours worked multiplied by hourly wage rates (accelerated to reflect leave and fringe benefit costs) plus overtime labor costs. Material costs include all material and supplies required for job completion. Contractual services involve off-station, contractor provided services such as rental space, utilities, equipment or research and development. Other costs include any costs that cannot be classified as labor, material or contractual services. Examples of other costs are travel, transportation and per diem expenses. [NAVCOMPT-A, 1985; NAVCOMPT-B, undated]

Within each of these cost categories, costs are treated as either direct or indirect. Direct costs are charged directly to specific job order numbers. Indirect costs are accumulated within the cost centers in overhead expense accounts and are later allocated to specific jobs on a direct labor hour basis. [NAVCOMPT-A, 1985; NAVSEA, 1984]

4. Overhead Allocation

As noted above, overhead expenses are "accumulated by the organization incurring the expense and are classified as to the category of expense (i.e. labor, material, contractual services or other) for purposes of cost control." [NAVCOMPT-A, 1985]

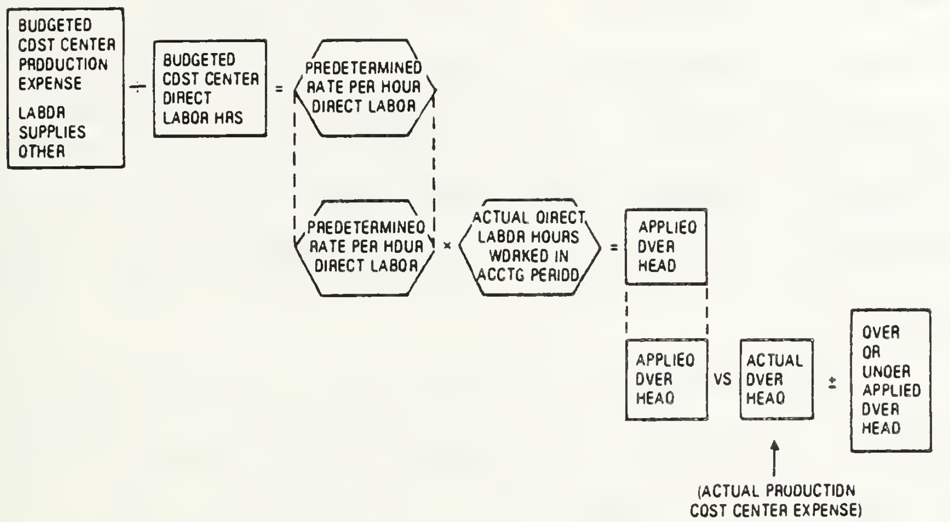
Since overhead expenses are not incurred at a uniform rate, NIF uses predetermined overhead application rates based on total direct labor hours worked on individual jobs to provide for uniform overhead distribution. Since overhead generated in a production cost center should be allocated only to those jobs worked in that cost center, NIF prescribes development of separate predetermined overhead application rates for each production cost center. A single overhead application rate is used for allocating General and Administrative overhead expenses. [NAVCOMPT-B, undated]

Figures 4-2 and 4-3, respectively, illustrate the process used for application rate determination and production and G&A overhead expense allocation.

5. Unfunded Costs, Depreciation, and Military Labor

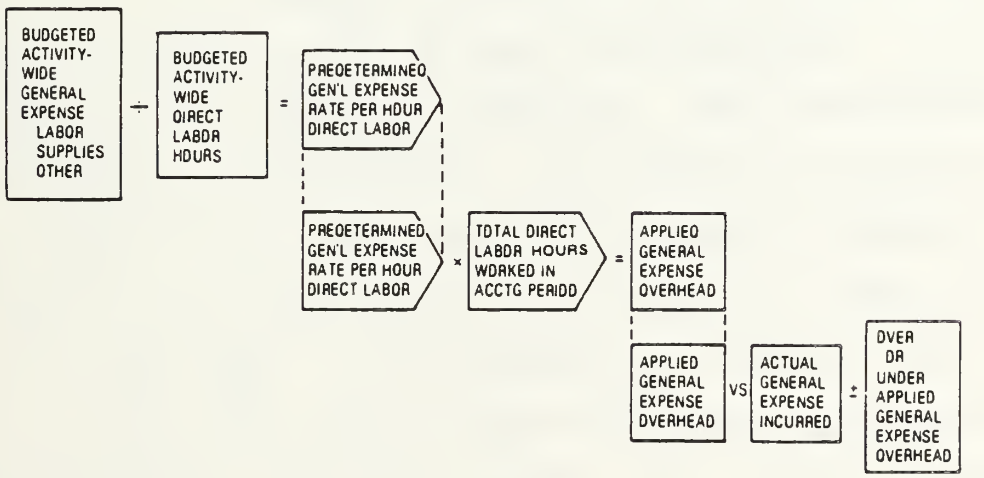
The existence of "unfunded costs" and the treatment of depreciation and military labor costs distinguish NIF from commercial cost accounting systems.

> Unfunded costs are those costs which do not result in any disbursements of cash on the part of the performing activity. They include such costs as depreciation on contributed plant/property and military pay and allowances. [NAVCOMPT-A, 1985]



Source: NAVCOMPT-A, 1985]

Figure 4-2 Application of Production Overhead



Source: [NAVCOMPT-A, 1985]

Figure 4-3 Application of General Expense Overhead

These costs are called statistical costs. They are collected for statistical purposes, but are not billed to government customers. They are, however, billed to non-government customers in the form of a surcharge called a statistical rate. The funded cost multiplied by the statistical rate represents the amount billed to non-government customers. [NAVCOMPT-A, 1985; NAVCOMPT-B, undated]

Plant assets acquired prior to 1982 are considered unfunded; therefore, their depreciation cost is included in the statistical rate, but is charged to non-government customers only. Those plant assets purchased after 1 October 1982 are considered funded and are depreciated on a straight line basis. These costs are included in overhead and are allocated to jobs as a part of billable cost. [NAVCOMPT-A, 1985; NAVCOMPT-B, undated]

Military labor used in NIF activities is considered an unfunded cost. Military labor cost is recorded statistically as described above and billed only to non-government customers. Although military labor cost is not charged to government customers, the military labor hours worked within a cost center are included as a part of the base in determining production cost center overhead rates. The total number of military labor hours worked in the organization are also included as a part of the base for

determining the activity-wide G&A overhead application rate. [NAVCOMPT-B, undated]

D. COST ACCUMULATION

The degree of automation used in cost accounting at the various NIF activities varies depending on the specific activity. The descriptions of the cost accumulation procedures listed below are generic in nature. They incorporate elements of both manual and electronic systems. The important consideration in this section, however, is cost flow, not record format. All figures depicting manual records are easily duplicated in an electronic format.

1. Customer Orders

In general, NIF activities should perform no work except on the basis of orders received and accepted. "Most work ordered from NIF activities is by Navy and other DOD components through the use of reimbursable orders." [NAVCOMPT-A, 1985] These reimbursable orders can either be Project Orders or Work Requests. [NAVCOMPT-B, undated]

The primary distinction between Project Orders and Work Requests lies in the type of work and the scope of the job to be performed. Another important distinction is that work on Project Orders can continue to completion even after the appropriation cited has expired. Work on Work Requests must cease on the cited appropriation's expiration date. The important point to be made here is that both documents represent an obligation of funds by the customer and, when

accepted, represent authority for the NIF activity to perform work. [NAVCOMPT-A, 1985; NAVSEA, 1984]

NAVCOMPT Form 2275, Order for Work and Services, with the appropriate box checked in block 13, is used for both documents. [NAVCOMPT-A, 1985] Figure 4-4 depicts a NAVCOMPT 2275 used as a Project Order.

2. Price Determination

All Project or Work Orders are accepted on either a fixed price or a cost-reimbursable basis. Regardless of the price basis, cost estimates are based on published stabilized rats for the specific product or service requested. These stabilized rates are established based on budgeted cost estimates. [NAVCOMPT-A, 1985; NAVCOMPT-B, undated; NAVSEA, 1984]

Depending on the work required, stabilized rates may be quoted as a rate per man-day or a rate per labor hour worked. Customers are billed at the stabilized rate regardless of actual cost to perform the work. [NAVCOMPT-A, 1985; NAVSEA, 1984]

3. Customer Order Acceptance Record

Upon receipt of a project order or a work request the NIF activity establishes a Customer Order Acceptance Record (COAR). The COAR serves as authority for the performance of work based on acceptance of a reimbursable order and is a "cost accounting record established to control costs and serves as a billing record for the ordered

VOUCHER FOR DISBURSEMENT AND/OR COLLECTION—NAVCOMPT FORM 2277 (8PT) (2-81) S/N 0104-LF-702-2770 Page 1 of Pages

1. Purpose	2. Date	3. Reference Document No	4. Bill Number	5. Voucher No
DISB ☒ COLLECT ☐	15 Feb 1980	N6290080WR68601	31806	

6. FROM

Naval Ship Research and Development Center
Department of the Navy
Bethesda, MD 20084

7. PAID BY CHECK NO.

8. TO

Director
Naval Weapons Engineering Support Activity
ESA-19, Bldg 210-2, Washington Navy Yard
Washington, DC 20390

9. ARTICLES, SERVICES OR ITEMS

A. INVOICE OR ORDER NO	B. DATE OF DELIVERY SERVICE	C. DESCRIPTION (REMITTER, EXPLANATION, DETAILS, ETC.)	D. QUANTITY	E. UNIT PRICE COST	PER	F. AMOUNT
	Feb 1980	Work and Services				$ 63,020.15

G. DISCOUNT TERMS H. TOTAL

10. TYPE OF PAYMENT OR BILL COMPLETE ☐ PARTIAL ☐ FINAL ☐ PROGRESS ☐ ADVANCE ☐

11. ACCOUNTING CLASSIFICATION TO BE CREDITED (COLLECTION)

A. ACRN	B. APPROPRIATION	C. SUB-HEAD	D. OBJ. CLASS	E. BUREAU CONTROL	F. SA	G. AAA	H. TT	I. PAA	J. COST CODE	K. AMOUNT (U.S. CURRENCY ONLY)
	17X4912	3722	800	77777	0	000167	2E	000000	000016745800	$ 63,020.15

12. DEDUCTIONS

A. ACRN	B. TRANSPORTATION	C. DISCOUNT	D. TAX	E. RESERVE	F. MISCELLANEOUS	G. TOTAL FOR ACRN (U.S. CURRENCY ONLY)

H. CURRENCY EXCHANGE RATE =$1.00 I. TOTAL DEDUCTIONS

13. ACCOUNTING CLASSIFICATION TO BE CHARGED (DISBURSEMENT)

A. ACRN	B. APPROPRIATION	C. SUB-HEAD	D. OBJ. CLASS	E. BUREAU CONTROL	F. SA	G. AAA	H. TT	I. PAA	J. COST CODE	K. AMOUNT (U.S. CURRENCY ONLY)
AA	1761804	1374	000	62908	0	000171	20	000000	60986WRC8601	$ 63,020.15

L. TOTAL NET AMOUNT TO BE PAID (BLOCK 9-H MINUS BLOCK 12-I)

14. INSPECTION REPORT NOS 15. GOV'T B/L NOS

16. APPROVED

BY ______

______ TITLE ______
(DATE)

17. CERTIFIED

BY D. L. Jones

3-2-80 TITLE Accounting Officer
(DATE)

18. PAYMENT RECEIVED

PAYEE–
PER–
TITLE–

Figure 4-4 NAVCOMPT 2275 Used as a Project Order

work." [NAVCOMPT-A, 1985] A COAR is established for each separate item or major work segment contained in a reimbursable order which has a distinct appropriation billing citation. A five digit COAR number is assigned to each COAR established to identify the project. [NAVCOMPT-A, 1985; NAVCOMPT-B, undated; NAVSEA, 1984]

Figure 4-5 depicts a manual COAR containing the minimal information necessary to control cost and billings and avoid a section 1517 statutory violation for over-billing. [NAVCOMPT-A, 1985; NAVSEA, 1984]

4. Job Order Record

"A Job Order is the basic unit of the NIF cost accounting system used to collect and identify direct costs and to apply overhead to customer orders." [NAVCOMPT-A, 1985] A separate COAR is established for each item or major work segment within a reimbursable project order which has a distinct appropriation billing citation. Since more than one type of job is usually required to complete work within each COAR, a Job Order Record is established for each job and serves as authority to perform work, accumulate direct costs and apply overhead. Each Job Order Record is identified to the COAR. [NAVCOMPT-A, 1985]

Table 4-2 lists the functions performed by the Job Order Record. Figure 4-6 illustrates what a manual Job Order Record might look like.

NOFORN _____ YES _____ NO
COAR MEMORANDUM
CNSYD-7302/13 (11-87)

CODE	620
DATE	

FROM
Code

TO
Code 620

PREPARE/AMEND

COAR #	COAR REV.
	TOTAL AUTH. AMT
	FIXED MAT'L AMT
COAR TITLE	FUNDS ADM.
START DATE	COMP DATE
STD LABOR (620)	STAB. MAT'L (620)
	PROGRAM YEAR (620)
ORDER TYPE CR ☐ FP ☐	CHARGE CODE A ☐ M ☐
HULL TYPE	HULL NO.

AVAIL TYPE (RO/TA/RA/OO, etc.)

FP OFFER DATE	FP ACCEPT. DATE
OVERTIME CODE 400)	WORK CODE (I or D)
REPORT REQ. IND. (240)	C/B LINE (620)

DLA PROCESS CODE OR Y/N (620)

EXCLUDABLE OT
YES ☐ NO ☐

DOCUMENT NO.
BCN NO

WORK DESCRIPTION/REMARKS

FA (Signature) (1) ORIGINAL 620 (2) COPY FA (3) FOR PLANNING: CC TO 219 05	DATE

NOFORN _____ YES _____ NO

Figure 4-5 Sample Customer Order Acceptance Record

TABLE 4-2

FUNCTIONS PERFORMED BY JOB ORDER RECORDS

Job Order Records perform the following functions:

1. Specify to performing cost centers, shops, etc., the assigned task or operation to accomplish authorized work and to provide identification to which labor, material, overhead, etc., may be charged.

2. Contributes to the control of costs through the establishment of estimated costs for resources required and through subsequent comparison between cost estimates and actual costs incurred. Ideally the job orders should contain cost standards in lieu of cost estimates for performance of work. (Cost estimates or standards are not cost limitations.) Financial control is exercised at the customer order level. However, the total cost estimates or standards of all job orders pertaining to a specific Customer Order Record should not exceed the amount authorized or allocated for that Customer Order Record.

3. Obtain detailed classification of costs required by activity management planning and other management purposes and for external reporting to higher echelons.

4. Serve as authority to perform work and to incur costs at the cost center level.

Source: [NAVCOMPT-B, undated]

JOB ORDER
CHARLESTON NAVAL SHIPYARD

SHEET ______ OF ______

SHIP PROJECT	SHIP NO.	CONFIRMS NTA Date Time	JOB ORDER NO (ICN)	REV.

WORK I.D. PRIOR	AUTHORITY (WR, SA, OA, SWLIN, ETC.)	FINAL (F), NON-FINAL (NF)	CHG	VAL LVL LABOR / MAT'L	DMC NO.	SYSTEM NO

P & E NAME	I.D. NO.	PHONE	DATE	TYPE OF WORK	RIC

CHECKED BY P & E SUPV.	INITIAL & DATE	T.D. CODE	J.O. APPROVED	INITIAL & DATE

SCHEDULER	I.D. NO.	PHONE	DATE	JML TO SHOP (S)

JOB TITLE

SUB TITLE

JOB ORDER SEQUENCE (1) Level of Essentiality Status, (2) Sub-Safe Status, (3) Brief, (4) Reports Required - Shop(s) - Due Dates, (5) Special Material Instructions, (6) Related Job Orders, (7) Key Operation(s)/Line Item(s) Instructions, (8) Plans-Technical Directives - Issue Status, (9) Component Overhaul Sheet, (10) Enclosures.

LEVEL OF ESSENTIALITY

SUB-SAFE STATUS

JOB ORDER BRIEF

SHOP	COP	DIST	M. H.
130	5	5	
190	5	5	
240	6	6	
225.1	1	1	
365	3	3	
377	1	1	
378	7	7	
382	1	1	
600	1	1	
COV	3	3	
P&E	1	1	
FILE	5	5	
05	3		
06	4		
11	10		
13	XX	XX	
17	10		
19	XX	XX	
20	1		
21	1		
22	1		
24	3		
26	5		
31	9		
32	8		
33	XX	XX	
34	XX	XX	
35	XX	XX	
38	9		
39	XX	XX	
41	7		
51	10		
56	9		
62	XX	XX	
64	7		
67	10		
71	8		
72	7		
81	2		
99	4		
TOTAL			
MATERIAL TOTAL $			

SHIP (Work satisfactory) (Name)	DATE	CODE 210.11 INPUT (Initial)	AUDIT J62	L62	M62	DATE

SHIP SUPT PROGRESS (Work complete) (Name)	DATE	CODE 377 INPUT (Initial)	K62	DATE

6ND-CNSYD-4850/78 (Rev. 4-80)

Figure 4-6 Sample Job Order Record

5. <u>Job Order Numbers</u>

For each Job Order written, a Job Order Record is established and a job order number is assigned. This job order number is the means by which all job costs are ultimately related back to the COAR. It constitutes a subdivision of the COAR. Although various job order numbering systems are acceptable, all must indicate how costs are incurred and to whom or what they should be charged. [NAVCOMPT-B, undated]

Figure 4-7 is an example of a common job order numbering system.

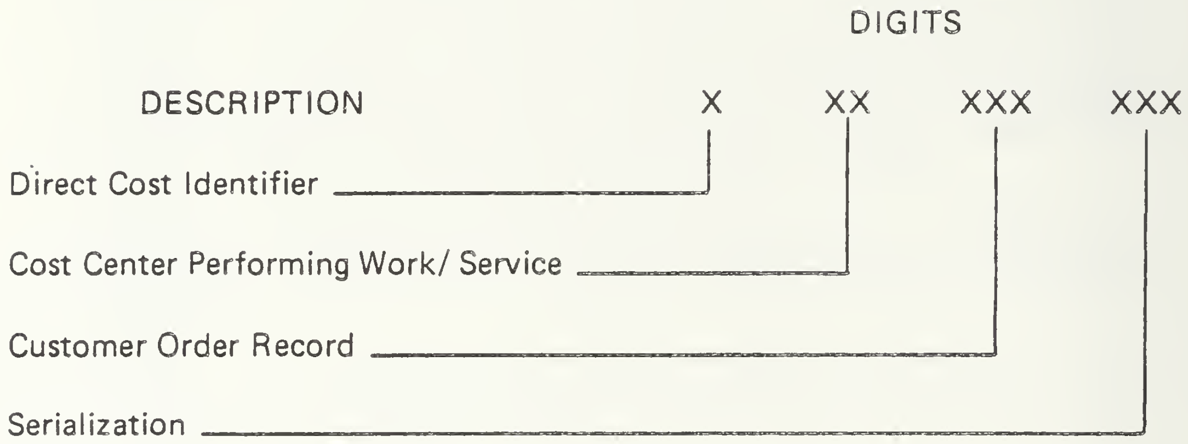


Figure 4-7 Sample Job Order Numbering System

6. Cost Collection and Cash Flow

Since work on any single job may be performed by many different cost centers within the activity, some method is necessary to collect the cost information and to summarize total job costs. This is accomplished by combining the job order numbering system with input documents for each cost element (i.e., material, labor, contractual services, other).

Labor costs are documented on labor distribution cards prepared by supervisors for each employee of his work center. Prepared on a daily basis, these cards record the number of direct labor hours worked on each job order. These labor costs are accelerated for leave and fringe benefits, and applicable production cost center and activity G&A overhead rates are applied to each direct labor hour worked. All costs are accumulated and maintained by job order number. [NAVCOMPT-A, 1985; NAVCOMPT-B, undated; NAVSEA, 1984]

Material costs are tracked and collected through the use of material requisitions for standard stock items and purchase orders for non-standard items. Each requisition and purchase order bear the job order number of the job for which the material is required. Material requisition and purchase order information is continuously recorded to specific job order numbers. The costs are then recorded in

the proper Job Order Record. [NAVCOMPT-A, 1985; NAVSEA, 1984]

"Other costs such as travel, contractual services, etc., incurred in performance of work pertaining to a specific job order are also recorded in the applicable Job Order Record." [NAVCOMPT-A, 1985] This is accomplished by assigning the proper job order number of individual documents, summarizing cost by job order number, and posting it to the appropriate Job Order Record.

Figures 4-8, 4-9 and 4-10, combined, illustrate the flow of cost through the system from the receipt of a customer order through customer billing at the completion of work.

7. Cost and Expense Accounts

> All direct costs and overhead expenses are controlled in total through four general ledger accounts, i.e., 4400-Service Center Costs, 4500-Direct Costs, 4600-Production Expenses and 4700-General Expense. [NAVCOMPT-A, 1985]

(As previously discussed, the account numbers are subject to change when the uniform chart of accounts is implemented at the activity level.) Costs and expenses are also classified by element (labor, material, contractual services, other), function and performing and benefitting organizations in order to provide financial data for internal and external management reports. Subsidiary records called subsidiary accounts are maintained by cost center and cost class to support entries to the General Ledger accounts. They are established to provide management data to respective cost or

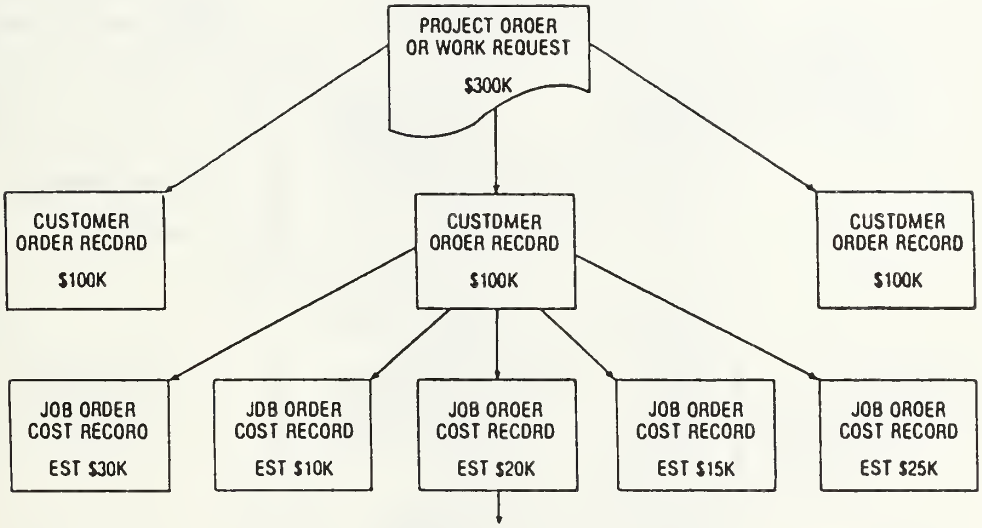
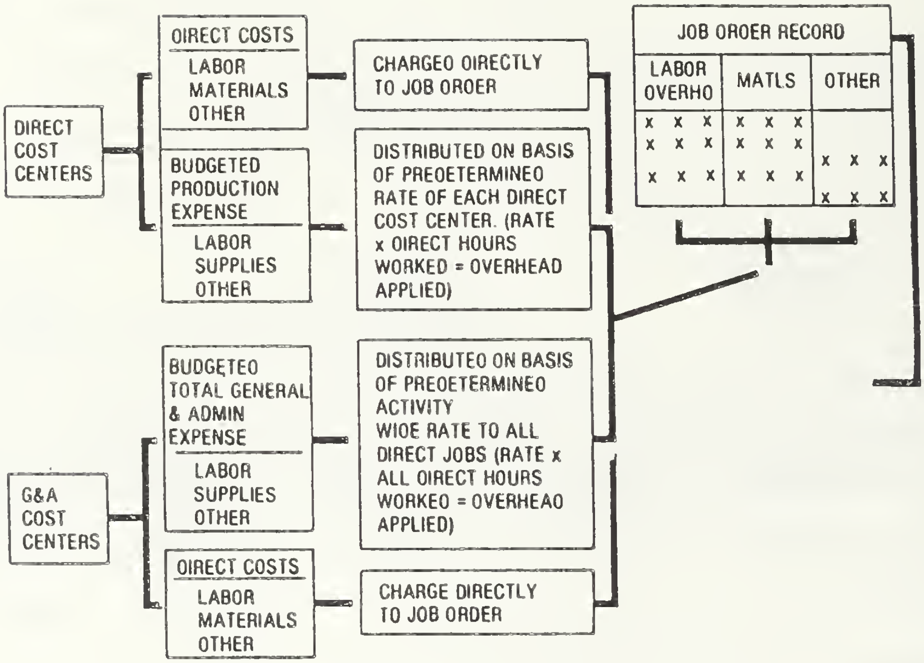
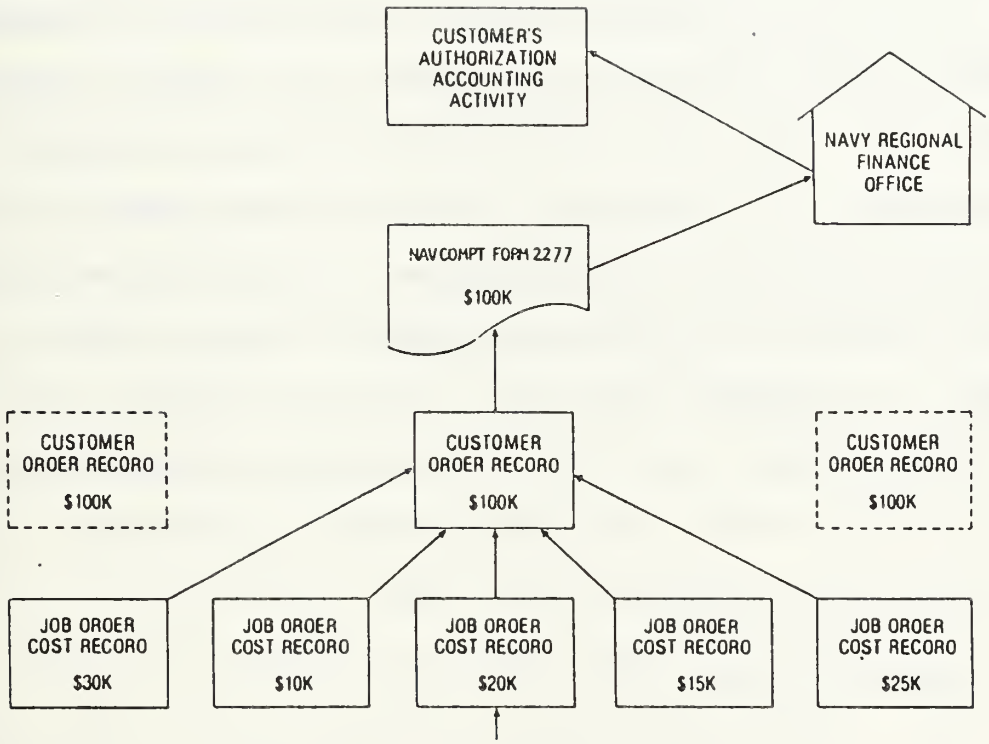


Figure 4-8 Cost Control and Job Order Estimating



Source: [NAVCOMPT-A, 1985]

Figure 4-9 Job Order Costing



Source: [NAVCOMPT-A, 1985]

Figure 4-10 Cost Flow Through Billing

expense center managers. [NAVCOMPT-A, 1985; NAVCOMPT-B, undated]

Costs and expenses are identified to their subsidiary accounts by assigning cost and expense account numbers which specifically identify each cost or expense transaction. Each direct cost transaction is assigned a subsidiary cost account code in addition to a job order number. [NAVCOMPT-A, 1985]

Each overhead expense transaction is assigned an appropriate expense account code. As overhead expenses are incurred, they are accumulated in these overhead expense accounts. By recording actual overhead expense, expense accounts play an important role in assisting managers with cost control by enabling managers to compare actual overhead cost to budgeted overhead. An SDR22 Budget versus Actual Report, which is a detailed overhead expense report, is provided to each cost center manager on a weekly basis for this purpose. [NAVCOMPT-A, 1985]

E. REVENUE COLLECTION

"All NIF activities price work and bill customers for work based upon the applicable stabilized rate (price) developed by the activity and as approved by the OSD Comptroller." [NAVCOMPT-A, 1985] DOD customer billings for work or services performed by the NIF activity are effected through the use of a Voucher for Disbursement and/or Collection (NAVCOMPT Form 2277). However, specific billing

practices and methods vary depending on the type of customer and appropriation funding the work. Figure 4-11 is a sample NAVCOMPT Form 2277. [NAVCOMPT-A, 1985]

Negotiated Fixed Price orders are based on the stabilized rates that are expected to be in force during the period that the work will be done. All fixed price customers are billed the negotiated price regardless of the actual cost to do the work. Any difference between actual costs and the billed price are reflected in the Accumulated Operating Results (AOR) account as a profit or loss. [NAVCOMPT-A, 1985; NAVSEA, 1984]

Cost Reimbursable Orders are billed on the basis of units of work completed multiplied by the unit stabilized rate. Work on the orders continues until the job is completed or until the billable cost equals the amount authorized on the customer's work order, whichever comes first. [NAVCOMPT-A, 1985; NAVSEA, 1984]

Prior to starting work on a customer order, NIF activities are generally provided with sufficient funds to support one and one-half months of work. Advance procurement of material for long-term projects is very expensive. Therefore, when an order costs more than $25,000, requires more than 30 days to complete and lies within specific income categories, activities are authorized to bill customers on a progress payment basis for costs accrued against and for the value of direct material

VOUCHER FOR DISBURSEMENT AND/OR COLLECTION—NAVCOMPT FORM 2277 (8PT.) (2-81) S/N 0104-LF-702-2770 Page 1 of Pages

1. Purpose	2. Date	3. Reference Document No.	4. Bill Number	5. Voucher No
DISB ☑ COLLECT ☐	15 Feb 1980	N6290880WR68601	31806	

6. FROM

Naval Ship Research and Development Center
Department of the Navy
Bethesda, MD 20084

7. PAID BY CHECK NO.

8. TO:

Director
Naval Weapons Engineering Support Activity
ESA-19, Bldg 210-2, Washington Navy Yard
Washington, DC 20390

9. ARTICLES, SERVICES OR ITEMS

A. INVOICE OR ORDER NO.	B. DATE OF DELIVERY/SERVICE	C. DESCRIPTION (REMITTER, EXPLANATION, DETAILS, ETC.)	D. QUANTITY	E. UNIT PRICE COST	PER	F. AMOUNT
	Feb 1980	Work and Services				$ 63,020.15

G. DISCOUNT TERMS H. TOTAL

10. TYPE OF PAYMENT OR BILL: COMPLETE ☐ PARTIAL ☐ FINAL ☐ PROGRESS ☐ ADVANCE ☐

11. ACCOUNTING CLASSIFICATION TO BE CREDITED (COLLECTION)

A. ACRN	B. APPROPRIATION	C. SUBHEAD	D. OBJ. CLASS	E. BUREAU CONTROL	F. SA	G. AAA	H. TT	I. PAA	J. COST CODE	K. AMOUNT (U.S. CURRENCY ONLY)
	17X4912	3722	800	77777	0	000167	2E	000000	000016745800	$ 63,020.15

12. DEDUCTIONS

A. ACRN	B. TRANSPORTATION	C. DISCOUNT	D. TAX	E. RESERVE	F. MISCELLANEOUS	G. TOTAL FOR ACRN (U.S. CURRENCY ONLY)

H. CURRENCY: EXCHANGE RATE =$1.00 I. TOTAL DEDUCTIONS

13. ACCOUNTING CLASSIFICATION TO BE CHARGED (DISBURSEMENT)

A. ACRN	B. APPROPRIATION	C. SUBHEAD	D. OBJ CLASS	E. BUREAU CONTROL	F. SA	G. AAA	H. TT	I. PAA	J. COST CODE	K. AMOUNT (U.S. CURRENCY ONLY)
AA	1761804	1974	000	62908	0	000171	20	000000	60986WR68601	$ 63,020.15

L. TOTAL NET AMOUNT TO BE PAID (BLOCK 9-H MINUS BLOCK 12-I)

14. INSPECTION REPORT NOS 15. GOV'T B/L NOS

16. APPROVED

BY ______

______ TITLE ______

(DATE)

17. CERTIFIED

BY D. L. Jones

3-2-80 TITLE Accounting Officer

(DATE)

18. PAYMENT RECEIVED:

PAYEE–

PER–

TITLE–

Figure 4-11 Sample NAVCOMPT Form 2277

received and reserved for specific orders. [NAVCOMPT-B, undated]

Progress billings are recorded as liabilities, not recognized as revenue, when they are posted. Not until work has been completed and the final bill has been processed is the liability liquidated and revenue recognized. [NAVCOMPT-A, 1985; NAVCOMPT-B, undated]

Costs which occur because work is not stopped when authorized funding has been consumed, resulting in total charges exceeding the amount authorized for reimbursement by the customer's work order, are known as unbillable costs. NIF activities must either receive additional authorization for an increase in customer's orders to cover unbillable costs or absorb them as an operating loss. [NAVCOMPT-A, 1985; NAVSEA, 1984]

F. COST CONTROL AND PERFORMANCE MEASUREMENT

Cost control and performance measurement are necessary to operate within fiscal constraints, identify problem areas, and provide incentives to lower-level personnel to make decisions consistent with mission objectives. Inherent in any NIF activity is the responsibility to produce quality products and services at the lowest possible cost. Cost performance measurement helps gauge whether or not the activity is meeting that goal. The cost performance measurement tools used by NIF activities include ratio and variance analysis, comparative analysis, trend analysis,

breakeven analysis, and financial statement analysis. [NAVCOMPT-A, 1985]

Ratio and variance analysis at both the total activity and cost center levels are effective cost performance measurement tools. Budgeted revenues and costs are compared with actual revenues earned and actual accrued costs through time-phased ratio analysis and variance computations.

> By translating any given period of time into a ratio and percentage, it is possible to compare the ratio of actual costs over budgeted cost for the same time frame...by comparing the percentages of both, it is possible to determine the variance from planned budget at that point in time. [NAVCOMPT-A, 1985]

As an example of the technique described above, assume two months of a given fiscal year have passed. The ratio and percentage of elapsed time equals 2/12 or roughly 17% of the year. If total budgeted cost for the same fiscal year equals $10,000 and actual cost accrued at the end of the two month period equals $2300, the ratio and percentage of accrued cost to total cost is equal to $2300/$10,000 or 23%. By computing the ratio of actual expenditure percentage over the time passed percentage, the variance of actual versus budgeted expenditures to date can be computed. In this instance 23%/17% is equal to 1.35 or a 35% variance over budgeted cost-to-date.

The degree of variance that is acceptable depends on the degree of cost efficiency desired and variability of operating conditions (e.g., seasonality) within the organization. However, significant variances require

investigation, explanation and corrective action when appropriate. [NAVCOMPT-A, 1985]

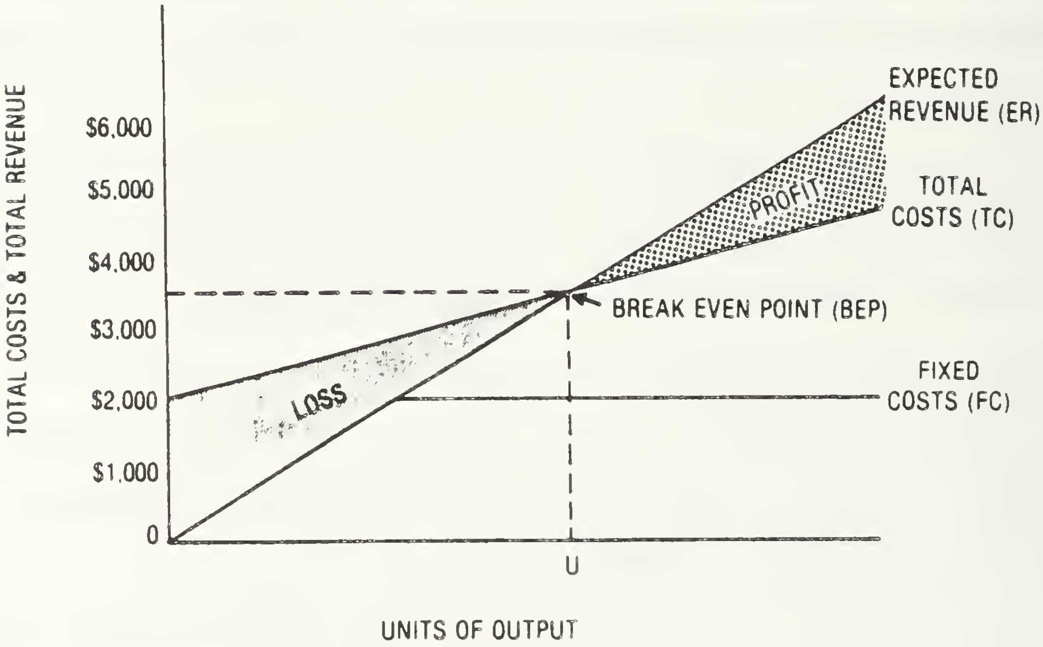
Comparative analysis consists of comparing one activity's or cost center's performance with that of another of similar type. Comparative analysis acts as a barometer against which to measure one's own performance. [NAVCOMPT-A, 1985]

Trend analysis is designed to highlight eroding or improving performance. Rather than providing a snapshot view of performance, trend analysis shows the same set of data from an historical perspective. This historical view allows management to see where changes in policies and practices are required to correct negative trends or effect positive ones. [NAVCOMPT-A, 1985]

Breakeven analysis highlights the relationships between revenues, cost, price and levels of production. The model takes into account that some costs vary directly according to the level of production, some costs are relatively fixed regardless of the level of production and some costs exhibit both fixed and variable characteristics. [NAVCOMPT-A, 1985]

Navy Industrial Fund managers have little control over the volume of workload received by their activities. As a result, instead of manipulating the level of production in order to breakeven, they must carefully manage their resources and control the production process so that costs

do not exceed revenues. Figure 4-12 illustrates breakeven analysis. [NAVCOMPT-A, 1985]



Source: [NAVCOMPT-A, 1985]

Figure 4-12 Sample Breakeven Chart

As in the private sector, operating results for NIF activities are reported in a series of financial statements. For NIF, the Statement of Financial Condition represents the Balance Sheet, and the Statement of Revenue and Costs serves as the Income Statement. Figures 4-13 and 4-14 illustrate these two financial statements. [NAVCOMPT-A, 1985]

NAVY INDUSTRIAL FUND

STATEMENT OF FINANCIAL CONDITION

AS OF 31 MARCH 1977

ASSETS

Cash			$220,831
Accounts Receivable			150,929
Inventories			
Work-in-Process		$1,893,317	
Less:	Progress Payments	(1,714,362)	178,955
Direct Material		72,149	
Less:	Progress Payments	(53,833)	18,316
Other Materials & Supplies			143,766
Other Assets			18,077
TOTAL ASSETS			$730,874

LIABILITIES

Accounts Payable		$92,597
Accrued Expenses		
Salaries & Wages	$59,608	
Other	128,603	
Leave	140,545	328,756
Advances from Customers		
Governmental Agencies	$215,596	
Other	4,284	219,880
TOTAL LIABILITIES		$641,233

CAPITAL

Cash Allocation (NET)	$185,769
Assets Capitalized Less Liabilities Assumed	(57,267)
Accumulated Operating Results	(38,861)
TOTAL CAPITAL	89,641
TOTAL LIABILITIES AND CAPITAL	$730,874

Figure 4-13 Sample Statement of Financial Condition

NAVY INDUSTRIAL FUND

STATEMENT OF REVENUE AND COSTS

FOR PERIOD ENDING 31 MARCH 1977

Revenue (various sources)			$3,364,748
Direct Costs		$1,931,194	
Labor	$1,317,524		
Material	545,484		
Other (includes Contractual Services)	68,186		
Production Expense		466,842	
Labor	385,020		
Material	68,185		
Other (includes Contractual Services)	13,637		
General & Administrative Expense		1,054,879	
Labor	840,095		
Material	85,232		
Other (includes Contractual Services)	129,552		
Total Costs Incurred			$3,452,915
Less Cost of Items Manufactured for Inventory			(19,074)
Costs Incurred for Customers			3,433,841
(Increase) Decrease - Work-in-Process			(24,566)
Cost of Goods & Services Produced			$3,409,275
Operating Results			
Net Operating Results			(44,527)
Prior Year Adjustments			(2,228)
Adjusted Operating Results			(46,755)
Operating Results - Beginning of Year			7,894
Accumulated Operating Results			$ (38,861)

Figure 4-14 Sample Statement of Revenue and Cost

"The financial and operating statements reflect the entire operation of the activity in fiscal terms." [NAVCOMPT-A, 1985] Simple review of these statements can provide such information as the status of accumulated operating results (retained earnings), the existence of excessive inventories or the amount of overhead cost. However, ratio analysis of critical areas and comparison of these ratios with historical data and prescribed standards can highlight problem areas and indicate overall performance. For this purpose, NIF managers track various liquidity, asset utilization and inventory usage ratios while also keeping tabs on budget execution and conducting cash flow analysis. [NAVCOMPT-A, 1985]

G. CAPITAL ACQUISITION

The Fast Payback program was initiated to enable NIF activities to procure capital tools and production or support equipment (outside the PPBS system) to increase productivity and thereby decrease cost. Within a window of $5000 to $1,000,000, Naval Shipyards can invest in capital equipment which will improve productivity to an extent that the cumulative reduction of operating costs will result in full payback for the equipment within five years of its first operational use. [NAVCOMPT-B, undated; NAVSEA, 1984]

The Fast Payback Program requires an economic analysis for each investment to ensure that it meets the appropriate payback criteria. A uniform method for economic analysis is

not prescribed due to the unique nature of each investment decision. However, for each investment, a "Request for Fast Payback Procurement, Navy/Marine Corps Industrial Fund," as illustrated in Figure 4-15, is required to be forwarded to the appropriate level of the chain of command for approval. Following procurement, mid-term and post-term reports are required to report the equipment's actual performance relative to projected savings. Negative deviations from projected savings of greater than 25% are required to be explained. Activities must use existing industrial plant equipment (IPE) in place of new if it is available from the Defense Industrial Plant Equipment Center (DIPEC).

Interviews with NIF activity personnel indicate that capital investments initiated by the using activity for the purposes of equipment replacement or productivity improvement reasons are justified on the basis of a 10% internal rate of return (IRR). This 10% threshold is directed by the Naval Facilities Engineering Command (NAVFAC) publication NAVFAC T-442, Economic Analysis Handbook, of July 1980. An analysis is not conducted when investments are directed by higher authority in order to meet expanded mission requirements. [Interview-A, 1988; Interview-B, 1988]

H. SUMMARY

The foregoing description of the NIF system is a very limited overview. However, it is detailed enough to

REQUEST FOR FAST PAYBACK PROCUREMENT
NAVY/MARINE CORPS INDUSTRIAL FUND

PROJECT NO. 05-80	ACTIVITY XYZ Naval Shipyard/Ordnance Activity

PROJECT DESCRIPTION: (include present and proposed methods)
Purchase mechanical deck blasting equipment to remove deck coatings totaling 525,000 ft. in preparation for resurfacing. This type of work is currently contracted out at $.50 ft.2 for rough blasting and finished by shipyard personnel manually at an additional cost of $.25 ft.2. With the proposed equipment, the work can be done totally in-house at a cost of $.12 ft.2.

ESTIMATED COSTS:

Procurement	$70,000	Estimated Procurement Date	Jan 1980
Software	0	Estimated Operational Date	Feb 1980
Installation	3,000	Estimated Useful Life (yrs)	5
Transportation	2,000	Payback Period (mos)	8
Total	$75,000		

SUMMARY OF PROJECTED SAVINGS: (Detail on Page 2)	*CUMULATIVE BY YEAR AFTER OPERATIONAL DATE		
Cost Elements	FIRST YEAR	2ND YEAR	3RD YEAR
Direct Labor	$ 33,000	$ 66,000	$ 99,000
Direct materials	(6,500)	(13,000)	(19,500)
Other: Contractor Services	87,500	175,000	262,500
Maintenance	(2,000)	(4,000)	(6,000)
Utilities	(1,000)	(2,000)	(3,000)
Total Estimated (Increase)/ Decrease in Operating Costs	$111,000	$222,000	$333,000

REQUEST APPROVAL:

Prepared by:	John Doe	Date	9/17/79
Commanding Officer	Bill Smith	Date	9/17/79
Headquarters, Command		Date	
NAVCOMPT		Date	

* Naval shipyards should expand to five years in FY-82.

Source: [NAVSEA, 1984]

Figure 4-15 Sample Request for Fast Payback Procurement Navy/Marine Corps Industrial Fund

enumerate the basic characteristics of the system and will serve as an adequate model against which to consider the cost accounting issues raised in Chapter III.

V. AN ANALYSIS OF NIF'S ADEQUACY FOR USE WITH THE RAMP SMP FACILITY

A. INTRODUCTION

This chapter analyzes the NIF accounting system described in Chapter IV in terms of the accounting issues discussed in Chapter III. Issue by issue, the discussion examines NIF accounting's adequacy for RAMP SMP application.

As demonstrated in Chapter II, the RAMP SMP facility is an automated manufacturing facility best described as a Flexible Manufacturing System (FMS). As an FMS, the same cost accounting issues described in Chapter III which relate to automated manufacturing environments apply to RAMP.

Additionally, as pointed out in Chapters I and IV, accounting for the RAMP SMP facility is the responsibility of the NIF cost accounting system, which is based on traditional job order cost accounting principles. Therefore, the same accounting problems inherent in using traditional cost accounting systems for commercial automated manufacturing systems potentially exist when using the NIF accounting system for RAMP.

Issues are discussed in the following order: first, issues not addressed by the NIF accounting system; second, issues adequately addressed by NIF for RAMP application; third, issues inadequately addressed by NIF; and finally, related issues. Amplifying information is added where

necessary to explain peculiarities of the shipyard environment.

B. ISSUES NOT ADDRESSED BY THE NIF ACCOUNTING SYSTEM

The Learning Curve Effect is not addressed by the NIF accounting system. There was no mention of the Learning Curve Effect in any NIF publication reviewed, and interviews with shipyard personnel confirmed that Learning Curves are not computed.

Shipyard work entails a wide variety of work on a diverse group of ships. No two overhauls are exactly alike. Therefore, application of a Learning Curve to specific types of overhauls is not possible. [Interview-A, 1988]

This failure to compute a Learning Curve has minimal negative effect on the NIF accounting system's adequacy for RAMP. Some Learning Curve Effect will exist for the start-up and operation of the RAMP SMP facility as a whole. For instance, Learning Curves will affect the human element involved in such activities as CAD/CAM subsystem operation and equipment maintenance. However, once the system is fully operational, small lot sizes, the insignificance of labor, and the repetitive nature of the computerized manufacturing process will eliminate most of the impact of the Learning Curve Effect on product cost.

C. ISSUES ADEQUATELY ADDRESSED BY THE NIF ACCOUNTING SYSTEM

As discussed in Chapter III, automated manufacturing techniques decrease the total amount of labor required in the manufacturing process and change the nature of many labor-related costs from variable to fixed. Since labor-related costs in a Flexible Manufacturing System (FMS) are primarily fixed, variable cost as a percentage of total manufacturing cost is sharply decreased. Variable costs are essentially limited to material, utilities and operating supply cost. As a result, traditional variable costing is less meaningful.

Traditionally, fixed and variable costs are considered from a short-term perspective, and costs are considered variable in the short-term view if they vary in relation to some underlying level of activity. Conversely, fixed costs have traditionally been viewed as those which are not affected by changes in activity level within some relevant range of activity. Cooper and Kaplan suggest that the short-term view of fixed and variable costs may be inappropriate for the automated manufacturing environment. Cooper and Kaplan argue that many costs, such as support department costs, which have traditionally been considered fixed, are actually variable in the long-term. These costs are not variable in relation to the level of production; rather, they are variable in relation to the range of products produced and the complexity of the manufacturing process.

In general, the wider the range of products produced and the greater the complexity of the manufacturing process, the more variability these costs exhibit. Cost variability is transaction driven instead of volume driven. As a result, Cooper and Kaplan recommend that transaction related allocation bases be used for allocating these costs in an absorption costing system. Furthermore, since these costs are transaction related, accounting systems should be used which identify these cost drivers. [Cooper et al., 1987]

While the benefits of variable costing in its traditional role are recognized in NAVCOMPT Volume 5, the NIF accounting system, as used in the shipyard environment, does not isolate fixed and variable costs. [Interview-A, 1988; Interview-B, 1988] Since absorption costing is required for use with automated facilities, and since NIF activities already use absorption costing, the fact that the NIF accounting system does not isolate fixed and variable costs has minimal negative impact on its adequacy for use with the RAMP SMP facility. However, it is important for NIF activities to be aware of the transaction and time related variability of many costs they previously considered fixed. They should be prepared to address the impact these changes have on cost allocation and cost control information considerations. Cost allocation and cost control considerations are both discussed below.

D. ISSUES INADEQUATELY ADDRESSED BY THE NIF ACCOUNTING SYSTEM

1. Direct vs. Indirect Cost

As discussed in Chapter IV, NIF accounting recognizes the difference between direct and indirect costs and applies them to each job in a manner appropriate for traditional job order cost accounting systems. NIF's definition of direct cost is essentially the same as the traditional definition in that it refers to direct costs as those that can be directly linked to final products or services.

As indicated in Chapter III, this traditional definition of direct cost results in decreased direct cost and increased indirect cost when it is applied in an automated manufacturing environment. This change occurs because direct labor costs are reduced and a more significant portion of total product cost becomes equipment related. Some previously employed direct labor is replaced by specialized support staffs which increase indirect labor costs. The subsequent increase in the proportion of total costs which must be allocated, because of the arbitrary nature of the allocation process, obscures true product cost.

Cost visibility for materials cost and general and administrative (G&A) expenses would not be obscured by continued use of the traditional definition for direct cost. Material cost would continue to be treated as direct, and

there is virtually no effect on G&A expense. Product cost becomes obscure because of the traditional definition's treatment of direct labor and depreciation.

Direct labor, including associated payroll tax and fringe benefit cost, is no longer a large part of product cost. The direct labor element (such as machine operators) in the man-paced environment is largely replaced in an FMS by highly skilled, highly paid system technologists, system operators and maintenance personnel. These costs are considered indirect costs under the traditional definition and must be allocated. Furthermore, as a larger percentage of total manufacturing cost becomes equipment related, depreciation expenses increase as a percentage of product cost. The increased depreciation and indirect labor costs are both elements of production overhead. Therefore, production overhead increases as a percentage of product cost. Since production overhead must be allocated, and since allocation is an arbitrary process, true product cost becomes obscure.

Since the existing NIF definition of direct cost would result in decreased cost visibility if used with RAMP, and since cost visibility is paramount to good cost control, NIF's definition of direct and indirect cost is inadequate for RAMP application. Alternative approaches, such as the adoption of Allen Seed's definition of direct cost, as described in Chapter III, should be considered. By updating

the definition of direct cost and ensuring the RAMP SMP computer system can provide accurate cost data, the NIF accounting system could enhance its ability to identify direct relationships between costs and products. This would minimize cost allocation and more clearly identify true product cost within the RAMP SMP system.

2. Allocation of Indirect Cost

As prescribed by NAVCOMPT Volume 5, the NIF accounting system uses direct labor hours as the basis for allocating all production and general overhead expense. This method of overhead allocation is inadequate for use with RAMP.

As explained in Chapter III, because direct labor is only a small percentage of total product cost in the FMS environment, using direct labor hours for overhead allocation means losing the cause and effect relationship essential to sound cost allocation. Product cost in an FMS bears little relation to the amount of direct labor used in the manufacturing process. Therefore, using direct labor hours (as prescribed for NIF accounting) for overhead allocation in the RAMP SMP facility would result in an inappropriate cost allocation and inaccurate product pricing.

Since the NIF accounting system's method for allocating indirect cost is inadequate, alternative bases, which preserve the proper cause and effect relationship

between the allocation base and the cost object should be considered. Table 3-2 lists four of the allocation bases most commonly used in the automated manufacturing environment and discusses the advantages and disadvantages of each. Consideration should be given to using multiple allocation bases. Using multiple bases would allow the use of the most appropriate allocation base for each category of overhead cost in order to maximize the cause and effect relationship between the overhead cost and the end product.

3. Cost Control

As discussed in Chapter III, the system technologist is responsible for both cost control and operational control in an FMS. These two factors are closely related in that operational control decisions affect the cost of production and render production cost beyond the control of production managers on the plant floor. Because of this relationship, an FMS's accounting system must be able to provide system technologists with the information necessary to identify the procedures and operational elements which are the true causes of cost (the cost drivers) so that the non-value activities discussed in Chapter III can be eliminated.

Cost center managers are responsible for cost control in the NIF accounting system. NIF accounting cost control is accomplished by comparing actual and budgeted costs. Variances between actual and budgeted costs are

examined, and, when material, they are investigated, explained and corrective action is taken.

The fact that cost control is the responsibility of system technologists in the automated manufacturing environment while it is the responsibility of cost center (production) managers in the current NIF accounting system presents a problem. Since many FMS costs are beyond the control of production managers, they should not be held responsible for controlling those costs. Conversely, since the NIF system does not provide the cost driver information required for cost control by system technologists, the technologists cannot be held responsible for controlling production cost. As a result, there is no mechanism for cost control if the current NIF accounting system is used in an FMS environment.

Because of the problem cited above, the NIF accounting system in total is considered inadequate for use with the RAMP SMP facility. The NIF accounting system requires enhancement to provide cost driver information for system technologists' use in cost control activities. The system must be further changed to clearly identify those costs which remain under the control of cost (production) center managers and to provide for flexible budgeting techniques and resulting variance analysis to help control those costs. The Cost/Schedule Control System (C/SCS) is used as a separate system to support cost control at

shipyards for major projects such as ship overhauls. Since C/SCS is designed to support major, large scale projects, it is not appropriate for use with a RAMP SMP facility which operates as a cost center within a shipyard. As a result, C/SCS does not improve the NIF accounting system's adequacy for use with the RAMP SMP facility.

4. Performance Measurement

The summary of performance measurement for the automated environment provided by current literature identifies the problems involved with using traditional performance measures for automated systems. As concluded in Chapter III, new multi-dimensional performance measures which are easy to understand, contain both financial and non-financial indicators, and which identify cost drivers and focus on quality should be developed. Table 3-5 provides a list of alternative performance measures which could improve performance measurement in an FMS and make the measures more meaningful.

In the NIF accounting system, performance measurement and cost control are closely related. The variances computed for cost control are also used for performance measurement. Comparative analysis, trend analysis, breakeven analysis, along with ratio and variance analysis are the tools used by NIF for performance measurement throughout the various levels of the organization. These

measures are valuable indicators of financial performance, but they do little to address broader performance issues.

Although other programs and systems within NIF activities (such as the Quality Assurance program and C/SCS) may consider such issues, based on the literature reviewed and the analysis conducted, the author found no evidence that the NIF accounting system itself measures performance parameters like worker productivity, performance against schedule, or quality control. Neither is there any evidence that NIF's financial performance measures identify cost drivers.

For these reasons, the NIF accounting system alone does not adequately meet the performance measurement requirements for use with the RAMP SMP facility. The questions which remain to be answered are: What performance measurement functions are performed by other systems within the organization? Do these systems' performance measurements meet RAMP's needs? If not, should responsibility for these functions be made a part of NIF's accounting system?

5. <u>Information Requirements</u>

One of the most difficult aspects of this analysis has been distinguishing between the NIF accounting system and the NIF activity's management information system (MIS). As discussed in the performance measurement section of this chapter, many other systems within a given NIF activity

interact with or perform functions related to the NIF accounting system.

The management information system as well as the NIF accounting system in a typical NIF activity is a combination manual, batch and real-time system. Typically, more manual and batch capability are available than real-time capability. [Interview-C, 1988; Interview-B, 1988]

As indicated in Chapter III, manual MISs are inadequate for use with automated manufacturing processes because they are too slow, have questionable reliability and require continuous review. According to current literature, manual and batch systems fail to meet automated systems' needs for instantaneous feedback required for quality and process control, product costing, and performance measurement.

Since the NIF system is not yet fully automated with real-time capabilities, its adequacy for use with the RAMP SMP is questionable. Further study of RAMP's requirements for automated MIS and accounting systems is needed.

6. Capital Acquisition

As the discussion of capital acquisition for FMS investments contained in Chapter III disclosed, traditional discounted cash flow (DCF) techniques often fail to justify FMS investments because the hurdle rates are set arbitrarily high and because they overlook those savings that are less common or are more difficult to quantify. Kaplan recommends

using the opportunity cost of capital as the hurdle rate as a means of avoiding arbitrarily high rates; he suggests reversing the standard DCF technique so that intangible benefits can be considered in the decision making process. Kaplan's technique requires that, once unique FMS benefits are quantified and included in the cash flow analysis, standard discounted cash flow techniques are used to compute a net present value (NPV). If the resulting NPV is negative, the investor must determine how much annual cash flow must be increased before a positive NPV is achieved. The investor must then make a subjective judgment as to whether or not the intangible benefits to be derived from investing in the FMS are at least as much as the amount that cash flow must be increased.

As discussed in Chapter IV, NIF uses a 10% hurdle rate for justifying capital investments as directed by NAVFAC. Using this 10% hurdle rate complies with Kaplan's intent of lowering the hurdle rate to eliminate arbitrarily high rates and to more fairly project the financial contributions of FMS investments in later years. However, is NIF's 10% hurdle rate criterion arbitrarily low? Just as high hurdle rates can penalize FMS investments by understating their cash flow contributions in later years, arbitrarily low hurdle rates can make the investments appear overly attractive by over-stating their long-term cash flow contributions. Therefore, if the prescribed 10% hurdle rate

is too low, the Navy could potentially make unwise FMS investments based on over-stated long-term cash flow expectations.

Secondly, whether or not a 10% hurdle rate is used, payback must be accomplished within five years. This short-term approach makes it possible that FMS capital investments which provide substantial long-term benefits will be disapproved because their true benefits are recognized in the long-run, not in less than five years. Given a five year payback, long-term benefits might never be considered.

Thirdly, using Kaplan's technique would mean that FMS investments could potentially require justification by subjective judgments of the value of intangible contributions and their ability to overcome shortfalls in quantifiable benefits. Because of this element of subjectivity, it is possible that Kaplan's recommended technique of reversing the standard DCF procedure may not be readily accepted within the NIF chain of command.

Current literature clearly indicates that private industry is still trying to determine the proper method for making FMS related capital investment decisions. While Kaplan offers one approach, that approach has not received universal acceptance as the answer to the problem. Certainly NIF capital acquisition techniques were not designed with automated manufacturing systems in mind. For these reasons, the NIF accounting system's approach to

capital acquisition must be considered inadequate for use with RAMP, and determination of the proper method for making capital investment decisions within NIF is recommended as a topic for further study.

7. Quality Control

The NIF accounting system is the conduit through which costs for quality control are accumulated. By highlighting quality control costs, the NIF system assists in quality control. The central question regarding NIF accounting's adequacy for RAMP application in support of quality control is whether or not it collects the proper types of cost information.

The focus of Chapter III's discussion of quality control for FMS was on the positive effect of FMS's production consistency on the overall level of quality. This consistency of output from automated manufacturing processes shifts quality control focus toward tracking customer acceptance, control of input to the manufacturing process, in-process auditing, and determining the total cost of non-conformance. NIF accounting must be able to provide cost data for each of these quality control efforts.

NIF accounting already collects quality control cost data in cost and expense accounts by recording costs using the proper cost account codes. The system's ability to collect costs related to controlling input into the manufacturing process is demonstrated by its current

accounting for the costs of the SUBSAFE, Level I, and nuclear material quality control inspection programs. These costs are accounted for with no special modifications to the NIF accounting system.

The remaining three categories of cost information, the cost of customer acceptance, the cost of in-process auditing, and the total cost of non-conformance are not as readily available through NIF. While it can be indirectly gauged by tracking the cost of re-work and scrap, NIF does not specifically track the level of customer acceptance. Neither is the total cost of non-conformance readily available. Determining the cost of non-conformance involves consideration of cost factors outside the shipyard environment. Total cost of non-conformance in a shipyard environment could include a diverse variety of costs ranging from additional labor, material and overhead costs resulting from re-work to the indirect costs related to the impact of non-conformance on a ship's operational schedule, its inability to meet mission requirements, or loss of a warfighting capability. NIF accounting is not currently designed to collect these types of costs, but is limited to tracking and manipulating costs recorded in quality control related cost and expense accounts. Finally, NIF was not designed to collect cost information from in-process audits. Determining the cost of in-process audits would require tracking the cost of quality checks made by automated

manufacturing equipment. The system would have to insure that these quality control costs were segregated and clearly identified by the RAMP control system for input to the NIF accounting system.

Given that the NIF accounting system does not collect the types of information discussed above, its ability to support RAMP's quality control requirements is considered inadequate. Those changes that should be made to the NIF system in order to make it adequate in this area should be the focus of continuing study.

E. RELATED ISSUES

One important issue related to NIF accounting but not discussed in Chapter III is the effect operating losses by the RAMP SMP facility would have on the host shipyard. If the RAMP SMP facility is installed as a normal cost center in an existing shipyard, its individual financial performance would directly affect the shipyard's overall financial posture. Although economic analyses have been conducted, no NIF activity has actually operated a RAMP SMP facility. The profitability of a RAMP SMP facility is not guaranteed. There would be both short-term and long-term effects on the shipyard as a whole if the RAMP SMP suffered operating losses.

In the short-term, an unprofitable RAMP SMP operation would result in a reduction of the NIF Corpus. As explained in Chapter IV, NIF activities operate on a breakeven basis.

The shipyard mechanism for recovering from operating losses is to increase its overhead application rate. This rate is used in setting the shipyard's stabilized manday rate for new projects and work orders. Since stabilized rates are set two years in advance, the positive impact of increased overhead application rates is not reflected in revenue for two years. As a result, operating losses by a RAMP SMP facility would have to be absorbed by the shipyard and would be reflected as a decrease in the NIF Corpus. Decreasing the NIF Corpus could have serious cash flow implications and could potentially result in a disruption of the activity's NIF operating cycle.

In the long-term, RAMP operating losses could affect the shipyard's competitive position. As indicated above, overhead application rate increases are reflected in stabilized rates two years later. Since shipyards bid competitively for much of their workload, increasing stabilized rates could potentially render the shipyard non-competitive when bidding for new workload.

For these reasons, until the RAMP SMP facility's profitability is proven, consideration should be given to isolating its operation financially from normal shipyard operations so that its financial performance does not negatively impact its host shipyard.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The purpose of this thesis was to determine the adequacy of the Navy Industrial Fund (NIF) accounting system for use with the RAMP SMP facility. Accomplishment of this goal involved a series of logical steps, each of which required substantial research.

Chapter I introduced the thesis objective and discussed the changes caused by automated manufacturing techniques which render traditional cost accounting systems inadequate. The chapter introduced the RAMP Project, described the RAMP facility as an automated manufacturing system, and discussed the NIF accounting system's responsibility for RAMP accounting. Finally, Chapter I explained why a review of NIF accounting procedures was necessary to ensure their adequacy for use with the RAMP SMP facility.

Chapter II was the result of an in-depth study of automated manufacturing technology and the details of the RAMP SMP facility. The intent of this chapter is to gain an understanding of the technology which so greatly impacts cost accounting requirements and to validate the fact that the RAMP SMP facility does in fact incorporate this technology. By identifying the RAMP system as a flexible manufacturing system, the author determined that those cost

accounting issues which relate to generic FMS facilities also pertain to the RAMP facility.

In order to determine whether or not NIF accounting is adequate for RAMP, it was important to gain a clear understanding of the accounting issues related to automated manufacturing techniques. The accounting issues documented in Chapter III were a primary ingredient of the analysis in Chapter V. The other ingredient of the analysis was a firm understanding of the procedures used in and the operation of the NIF accounting system. The operation of the NIF accounting system was documented in Chapter IV.

Chapter V provided the analysis necessary to determine whether or not the NIF accounting system is adequate for use with the RAMP SMP facility. In Chapter V, the operation of the NIF accounting system was reviewed relative to the issues raised in Chapter III. The analysis determined that NIF's treatment of the Learning Curve Effect and Fixed and Variable costs is adequate for use with RAMP. However, for the remaining issues, including determination of direct and indirect costs, allocation of indirect costs, cost control, performance measurement, capital acquisition, and quality control, the existing procedures used by the NIF accounting system were found to be inadequate.

Based on the large proportion of inadequacies discovered in existing procedures, the NIF accounting system as a whole

is considered inadequate in its present state for use with the RAMP SMP facility.

B. RECOMMENDATIONS

The scope of this thesis was limited to determining the NIF accounting system's overall adequacy for use with the RAMP SMP facility. However, inherent in the analysis was the identification of specific problems pertaining to NIF's ability to cope with the accounting issues related to automated manufacturing. For many of these problems, specific requirements and potential solutions were discussed in Chapters III and V. The following paragraphs identify topics which are recommended for further study, discuss various considerations for inclusion in those studies, and present potential alternative solutions to some of the problems addressed.

How should direct and indirect costs be defined by the NIF accounting system for use with the RAMP SMP facility? Using the traditional definition of direct and indirect cost with RAMP will result in a loss of product cost visibility because of the increased requirement for cost allocation. The NIF accounting system's cost collection capabilities must allow costs to be directly identified to output; cost allocation must be minimized. Further study is necessary to determine if Seed's definition is adequate to meet RAMP's needs or if a better alternative solution exists.

What is the overhead allocation base to be used by NIF for the RAMP SMP facility? Because NIF accounting allocates overhead on a direct labor hour basis, and since a direct labor hour allocation base is unsuitable for use with automated manufacturing systems, NIF activities operating RAMP SMP facilities must be allowed to use alternative allocation bases. Units of production, total time in the FMS, engineered machine hours and actual machine hours are the four alternative allocation bases (c.f., Table 3-2) most commonly used in commercial FMSs. Each of these allocation bases has advantages and disadvantages, but, because of the ease of data collection and its ability to measure a product's use of each machine tool's productive capacity, the author considers actual machine hours to be the best of the four alternatives. However, consideration should not be limited to those four alternative bases. Consideration should also be given to other bases including transaction-related allocation bases which relate overhead costs to specific cost drivers. Perhaps the best solution is to use multiple allocation bases, choosing the most appropriate allocation base for each category of overhead cost in order to maximize the cause and effect relationship between the various overhead costs and the end products.

How should the NIF accounting system's approach to cost control be changed to adapt to the RAMP SMP facility's needs? Changes must be made within the NIF accounting

system before it can adequately support the RAMP SMP facility. The focus of cost control must shift from the production manager to the system technologist and system operation. Instead of focusing on past performance cost data, the system should identify cost drivers. The accounting system should provide operational information as well as cost data, and it should highlight the relationship between the two. In doing so, those elements of the manufacturing operation which are responsible for generating cost could be clearly identified and non-value added activities could be identified and eliminated where possible. In addition, those costs which remain under the direct control of the production manager should be clearly identified and appropriate cost control measures developed.

What role should the NIF accounting system play in performance measurement for the RAMP SMP facility? Performance measurement in shipyards is accomplished through other systems in addition to the NIF accounting system. The NIF accounting system provides only financial performance measurement data. In contrast to what the NIF system provides, Table 3-5 lists 15 alternative performance measures considered well-suited to automated manufacturing systems. Of those 15 performance measures, only three are related to financial performance; the rest are primarily related to operational performance. As a result, it is unclear what role the NIF accounting system should play in

performance measurement for RAMP. Therefore, redesign of the NIF accounting system's performance measurement function for use with the RAMP SMP facility cannot be accomplished until the facility's performance measurement requirements are clearly defined. Once RAMP's performance measurement requirements are known, it must be determined which requirements the NIF accounting system is responsible for and which must be met by other operational performance measurement systems. Based upon the recommended performance measures contained in Table 3-5, the author believes that, unless the NIF system's contribution to performance measurement is small and limited to cost-related data, substantial change will be required to enable the system to provide the necessary types of information.

What are the RAMP SMP facility's information system requirements for data collection and accessibility, and how should the information system interface with the NIF accounting system? A detailed study of RAMP's information requirements is currently underway. However, from a superficial view based on the requirements discussed in Chapter III, it appears obvious that automated manufacturing systems require real-time automated information systems. Furthermore, there apparently is no standard level of automation in NIF activities; those automated capabilities that do exist are primarily batch oriented systems. As a result, those elements of a NIF activity's information

system which interface with the operations of a RAMP SMP facility must be upgraded to a real-time system before efficient operation can be achieved.

What is the proper capital acquisition analysis technique to be used for FMS investments? Kaplan's discounted cash flow, net present value technique, with some modification, appears to be a reasonable method for evaluating Navy FMS investment opportunities. Using a 10% hurdle rate achieves Kaplan's objective of eliminating arbitrarily high hurdle rates. Although a 10% rate may be too small during times of high inflation, it is unlikely that the Navy can use a rate for FMS investments which is different from that prescribed for use throughout the government. Therefore, decision makers must be aware that the 10% rate may over-value cash flow contributions in the long-term during times of high inflation. During periods of low and normal inflation, the Navy should consider lengthening the five year payback period for Fast Payback Procurements, since one of the major benefits of an FMS investment is its long-term contribution to cash flow. Finally, decision makers should be well-versed in automated manufacturing, its advantages and its disadvantages before they undertake analysis of FMS investments so that the intangible benefits of the FMS can be considered in the analysis and proper subjective judgments of their values can be made.

What changes must be made in the NIF accounting system to enable it to collect the varied types of quality control costs recommended for automated systems? Since the focus of quality control shifts when automated manufacturing techniques are used different types of information are required. The NIF accounting system is not designed to provide data relative to customer acceptance, in-process auditing, or the total cost of non-conformance. Further study should determine exactly what information is required and whether providing that information should be the responsibility of the NIF accounting system or some other element of the management information system dedicated to quality control.

How can the RAMP SMP facility be operated so that, if the operation proves unprofitable, it does not negatively impact the financial operation of its host NIF activity? As discussed in Chapter V, because of the nature of NIF operations, an unprofitable RAMP facility could have a significant negative impact on the overall financial health of its host activity. As a result, until the RAMP SMP facility is proven to be a profitable operation, consideration should be given to isolating its financial performance from that of existing NIF activities. Three alternative approaches for operating the RAMP facility are: operating as an independent Government Owned-Government Operated (GOGO) NIF activity, operating as a cost center

within an existing NIF activity, and operating as a Government Owned-Contractor Operated facility (GOCO).

As an independent GOGO NIF activity, RAMP could operate under NIF funding, yet other activities would be isolated from the impact of its financial performance. The RAMP facility could still receive support services from shipyards as required, but those services would be provided to the RAMP facility on a user charge basis. One possible disadvantage of this alternative is the potential for high overhead costs associated with running an independent operation. A second disadvantage is that some changes in the NIF accounting system would be required to correct the inadequacies discussed above so that the system could adequately accommodate the RAMP SMP operation.

A GOGO RAMP facility operated as a cost center within an existing shipyard would also enable the operation to be NIF funded. This arrangement would allow the RAMP facility easy access to the full range of support services provided by a host shipyard, but it would expose the host shipyard to the financial risks discussed in Chapter V. This arrangement would also require changes to NIF accounting procedures. If those changes could be limited to the specific RAMP SMP cost center, then the effort required to effect those changes would be minimized. However, changes to specific cost center procedures are limited by the necessity for NIF accounting procedures to remain compatible with the

activity's management information system (MIS). If it proved impossible to limit NIF procedural changes to the specific RAMP cost center, the wisdom of changing the entire NIF accounting system to accommodate the RAMP facility is debatable.

The third alternative is to operate RAMP as a GOCO facility. Operating as a GOCO facility isolates NIF activities from financial risk, yet it still enables the Navy to set the facility's operating procedures, goals and objectives. GOCO frees the facility from the NIF accounting system and eliminates the need to make those changes in the accounting system discussed above. GOCO operation also frees the facility from Navy employment ceiling restrictions, existing agreements with labor unions, and an inability to respond quickly to changing workforce requirements. The major disadvantage of a GOCO operation is that the facility would no longer qualify for funding as a Navy Industrial Fund activity. Removing the operation from NIF funding requires that responsibility for contracting for and funding the RAMP operation be transferred to another activity, and funding for the operation would be subject to the Planning, Programming and Budgeting System (PPBS) and the annual appropriation process. Who is responsible, what the funding requirements are, and when, if at all, the funds would actually be made appropriated still must be determined.

Each alternative has its advantages and disadvantages. Further research should be conducted to determine which of these or other alternatives is the best operating arrangement for the RAMP SMP facility.

As stated above, the preceding discussion identifies areas requiring further study and presents points to be considered and alternatives to be reviewed as a part of those studies. Further study should resolve these questions, provide detailed solutions to specific problems, determine what changes must be made to the NIF accounting system so that it can adequately support the RAMP SMP system.

APPENDIX

RAMP SMP OPERATIONAL SCENARIO

The operational scenario presented in this appendix provides a detailed description of how the RAMP SMP facility might work when it is completed and in full operation.

A. ASSUMPTIONS

The operational scenario that follows is based on the following assumptions: The RAMP SMP facility is in full operation at a NIF activity. The Navy Supply Systems Command (NAVSUP), with input from the Inventory Control Points (ICPs), Hardware Systems Commands (HSCs), Type Commanders (TYCOMS) and the RAMP SMP activity itself, has selected and approved the parts families eligible for manufacture at the RAMP SMP facility. Parts selected for RAMP eligibility are characterized by small lot size, random demand, long leadtimes, or Diminishing Manufacturing Sources (DMS). [AMRC-A, 1988] Each eligible part is identified by a special code in the ICP's files so that it is recognized as a RAMP eligible part. The technical information necessary for engineering and production for each eligible part has been gleaned from blueprints, drawings and other specifications, digitized and converted into an electronic format called electronic part technical data (EPTD). EPTD packages for each part are stored in a technical database at

an EPTD Generation Facility for future use in the RAMP process. [Lotz, 1987]

B. SCENARIO

This scenario is reprinted from the RAMP SMP Operational Concept Document:

> A U.S. Navy ship is conducting a pre-deployment refit alongside a refit facility in her homeport. During routine preventive maintenance, her crew discovers that the upper bearing housing on a steering system hydraulic pump had been severely damaged as a result of bearing failure when the hydraulic oil in the steering system had been allowed to overheat. The ship's supply officer places a demand on the Naval Supply System by submitting a high priority MILSTRIP requisition to the cognizant Inventory Control Point. Since this particular piece of the steering system hydraulic pump had never required replacement during the 22 year operating lifetime of this ship or any other ship of the class, the bearing housing is not held as a repair part onboard the ship or in the Navy Supply System. The original manufacturer is out of business. The ship requires this repair part to go on deployment in about six weeks....The Inventory Control Point's automated files, which identify repair parts, will contain information which can verify that the needed part is a RAMP candidate. The Inventory Control Point will generate and transmit an order for the repair part in an automated electronic format to the RAMP site....
>
> When the requisition order for the bearing housing arrives at the SMP from the Navy Supply System, it will arrive in the required RAMP electronic format since communications in the SMP is essentially paperless...EPTD for the bearing housing will be sent to the RAMP SMP by the Navy EPTD Generation Facility. The order and the EPTD for the bearing housing is communicated via the RAMP SMP Information Management and Communication functional component, one to the five major functional components of the workcell system, to the Production and Inventory Control functional component.
>
> Production and Inventory Control extracts required electronic manufacturing information from the EPTD and forwards this information to the Manufacturing Engineering functional component. It also sends a shop work order for the bearing housing to the Manufacturing functional component.

Manufacturing Engineering determines process planning, shop equipment instructions, operator instructions, inspection/testing instructions, etc. If the part is not identical to one for which a process plan already exists, an existing plan, for a part within the same parts 'family,' will be selected as a basis to construct the new part plan. This determination is made by using rules for grouping of similar parts. Process planning personnel, utilizing a computer automated system, create the new process plan, using the existing plan as a base. The Manufacturing functional component will use this information and associated equipment instructions to effect actual manufacturing of the bearing housing on the shop floor. The Manufacturing Engineering functional component also generates tool, fixture and raw material requirements which are satisfied by assets on hand in the SMP facility or supplied by an outside activity.

The Quality functional component provides generation of quality reports, coordination of disposition of quarantined parts, assembly of part pedigree/certification, monitoring of equipment/personnel calibration/ certification, and monitoring of manufacturing processes from a process control/quality standpoint. Most of the required inspection/testing for the bearing housing will be completed during the shop floor manufacturing process. CNSY or contracted services will conduct required additional testing beyond the capability of the SMP process and personnel....

Using the process plans from Manufacturing Engineering, Manufacturing sends production commands for the bearing housing through the hierarchy of computer functions for cell, workstation, and shop equipment to control the actual manufacturing process. The cell processor determines shop floor routing for the bearing housing depending on machine and transport availability and priority. A repair part such as the bearing housing requires several manufacturing steps. These steps for the bearing housing will include raw material preparation, fixturing to an appropriate pallet, milling, drilling and boring on the horizontal machining center, unfixturing, refixturing, spot facing holes on the horizontal machining center again, unfixturing, deburring, washing, final inspection and packaging. Transportation from step to step on the shop floor will be primarily by AGV, although a roller conveyor will move the repair part through the wash, inspect, and package steps. The majority of the manufacturing process will be computer controlled with manual assistance primarily in fixturing and retooling as required.

Once the bearing housing has been manufactured and tested, operating personnel will package and ship the part via the Navy Supply System. [AMRC-A, 1988]

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